

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF NEW YORK

NEW YORK SMSA LIMITED PARTNERSHIP d/b/a
Verizon Wireless, NEW CINGULAR WIRELESS PCS,
LLC, and T-MOBILE NORTHEAST LLC,

No. 10-CV-4997 (AKT)

Plaintiffs,
v.

DECLARATION OF
EDUARDO ORELLANA

TOWN of HEMPSTEAD, and TOWN BOARD of the
TOWN of HEMPSTEAD,

Defendants.

X

EDUARDO ORELLANA declares as follows:

1. I am Eduardo Orellana, Director of Communications for RF / Wireless services for Integrated Strategic Resources (ISR). ISR is a consulting firm specializing in communications projects in the transportation industry. We are located at 505 8th Ave., Suite 2503, New York, New York, 10018. I submit this declaration on behalf of the Town of Hempstead (referred to as the “Town” throughout this affidavit).

2. This affirmation is made upon personal knowledge and information and belief, based on my investigation, communications with other ISR personnel, Town officials and representatives, and records and files relating to the configuration of cell phone towers, structural analyses of cell phone towers, compliance with Federal Communications Commission guidelines regarding Radio Frequency emissions, operations at cell phone towers, and building permit applications to the Town.

INTRODUCTION

3. For 11 years I worked in the cellular phone industry designing, as well as optimizing the performance of cell sites¹ for Nextel Communications, Sprint-Nextel, and Ericsson Services. In addition to Radio Frequency (RF) / wireless coursework as part of my Master of Science Degree in Electrical Engineering, I received internal training and equipment manufacturer training for four different RF technologies: iDEN (Motorola), CDMA (Alcatel-Lucent), UMTS (Ericsson), and Flash-OFDM (Flarion Technologies purchased by Qualcomm). I worked with internal site acquisition and construction departments for the build of more than 150 iDEN and CDMA cell sites, more than 100 of which I personally designed. As mentioned in Paragraph 1 above, as Director of Communications and as a Senior RF Engineer, I now work on RF / wireless projects in the transportation industry. I have also provided RF expert testimony in eleven criminal cases before the United States District Court for the Eastern District of New York. More details regarding my education, training, and experience are provided in my Curriculum Vitae attached in Exhibit A.

4. While at Sprint-Nextel, and subsequently at Ericsson as an outsourced engineer, we worked with construction managers who contracted architectural engineers that were responsible for the structural integrity of new cell sites and some types of cell site modifications. I would provide the base station equipment, coaxial cable, and antenna specifications that the architectural engineers needed to conduct their structural analyses. Because some rooftops could not support the steel dunnage required for base station equipment rooms in particular, we were sometimes

¹ Cell sites, also referred to as cell phone towers, consists of antennas that are mounted on rooftops, monopoles, lattice towers, water tanks, etc. with corresponding radio equipment (referred to as "base stations" throughout this affidavit) and the electrical and communications/coaxial cable needed to communicate with cell phones in the areas the site serve.

forced to look for an equipment room inside the building. Following a successful structural analysis for a new cell site, we would receive the construction drawings from our construction managers / architectural engineers for approval. However, for Sprint in particular, we were not required to request structural analyses for antenna swaps to improve service in an area.

5. Also while with Sprint-Nextel and Ericsson, we received internal training courses on the best approaches to complying with FCC OET Bulletin 65² regarding human exposure to RF emissions. Training included engineering solutions to reduce RF emissions on rooftops, and the proper way of measuring RF emissions. Some of the sites I designed required me to choose a higher point to mount antennas on a rooftop, like a bulkhead, or to request fencing around areas where anyone with access to the roof could walk in front of the antennas.

6. At the end of 2011, ISR was asked to assist the Town of Hempstead in understanding safety concerns that might exist regarding the building, modification, and/or operation of cell sites. At the time, the cellular industry was in the midst of deploying fourth generation (4G) networks, using new spectrum bands for deployment. The Town had begun to see an increase in the number of building permit applications as a result of the 4G deployments. Because of my experience described in Paragraphs 3 through 5 above, I suggested to the Town that we conduct audits / surveys to assess the "structural integrity" and "general and RF safety" at cell sites due to the addition of equipment, and to gather general information about equipment being deployed, such as operating frequencies and technologies.

7. ISR formed a team of Senior RF Engineers and Associate RF Engineers to conduct cell site audits, and review reports and drawings submitted to the Town, from 2012 through 2014.

² OET Bulletin 65 Edition 97-01, Authors Robert F. Cleveland, Jr., David M. Sylvar, and Jerry L. Ulcek "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Federal Communications Commission (FCC), Washington, D.C., Issued August 1997

In this affidavit, we discuss some of the key concerns we discovered as a result of our cell site audits and document reviews, which we summarize here:

- a. Only 1 of 51 structural analyses submitted to the Town was in accordance with the latest ANSI/TIA-222-G-2005 Standard, "Structural Standard for Antenna Supporting Structures and Antennas."³ The ANSI/TIA-222-G-2005 Standard has updated requirements for wind and ice loading, and structural analyses to this latest revision would determine if structural strengthening at cell sites is needed to prevent structural failures.
- b. 65% of the structural analyses reports submitted to the Town did not include any calculations as required by the Town of Hempstead General Code⁴.
- c. Structural analyses of ballast / sled mount rooftop antenna installations were not conducted using the latest ANSI/TIA-222-G-2005 Standard, which means the actual load that must be supported by the rooftop was not calculated correctly. Furthermore, four (4) ballast mount rooftop antenna installations, for which full analyses were submitted, required additional ballast load to safely secure the mount to the rooftop, but the Town was not advised if the additional ballast was added. Ballast mounts could move in high wind conditions if not properly ballasted, but also add loads that present a risk of rooftop structural failures if not properly engineered.
- d. Four (4) cell sites had coaxial cable runs that were not properly grounded because the ground bus bars were missing. When cable and equipment are not properly grounded,

³ ANSI/TIA-222-G-2005, "Structural Standard for Antenna Supporting Structures and Antennas", Published by Telecommunications Industry Association, August 2005, Effective January 1, 2006. ANSI is the American National Standards Institute, and TIA is the Telecommunications Industry Association. TIA is associated with the Electronic Industries Alliance (EIA) in representing the telecommunications industry.

⁴ "Town of Hempstead General Code", Legislation adopted through July 2013.

they present a risk of electrocution, as well as electrical and fire damage to equipment and property.

- e. Eight (8) Maximum Permissible Exposure (MPE) Compliance Evaluations (referred to as "MPE Reports" throughout this affidavit) submitted to the Town stated results were in compliance with FCC OET Bulletin 65 though the RF emissions calculations indicated otherwise and no action was suggested, and / or further action was needed to comply with FCC OET Bulletin 65. This is a risk to human health and safety.
- f. Fourteen (14) MPE Reports submitted to the Town stated results were in compliance with FCC OET Bulletin 65 though street level MPE calculations were incorrectly applied for rooftop installations. Therefore, the risk of exposure to high RF emissions on these rooftops was not evaluated, which presents a risk to the health and safety of workers and/or the general public accessing these rooftops.

In the paragraphs that follow, we will discuss in much more detail the concerns we have summarized. Two sites in particular that we visited, 2545 Hempstead Turnpike in East Meadow and 1975 Linden Boulevard in Elmont had multiple safety issues including coaxial cable that was not properly grounded and RF emissions above the MPE limits.

STRUCTURAL CONCERN: COMPLIANCE WITH ANSI/TIA-222-G-2005

8. As mentioned in Paragraph 4 above, as an RF Engineer working with various wireless service providers (referred to as "carriers" throughout this affidavit) I was always aware of the need to comply with structural requirements and standards, which was managed by our

construction management personnel. When we needed to add or swap out antennas and/or cable at cell sites managed by companies such as Crown Castle⁵, their service fees included a structural analysis to determine if our equipment could be added to the existing cell site, i.e., the structure could support the calculated loads. And when adding base station equipment to rooftops we would have to wait for a structural analysis to determine if steel dunnage to support the base station equipment could be supported by the existing roof structure.

9. In New York State, structural requirements for rooftop cell sites can be found in the 2010 Building Code of New York State⁶ (referred to as "NYS Building Code" throughout this affidavit), Chapter 31, Section 3108 for "Radio and Television Towers". Section 3108 references the ANSI/TIA-222 Standard which is the accepted industry standard applicable to both rooftop and free standing (monopoles, lattice towers, etc.) cell sites. As stated in the NYS Building Code, "code is intended to provide minimum requirements to safeguard public safety, health and general welfare through structural strength, means of egress facilities, stability, sanitation, adequate light and ventilation, energy conservation and safety to life and property from fire and other hazards attributed to the built environment." The ANSI/TIA-222-G-2005 Standard⁷ "provides the requirements for the structural design and fabrication of new and the modification of existing structural antennas, antenna-supporting structures, mounts, structural components, guy assemblies, insulators and foundations." Generally speaking, the NYS Building Code and

⁵ Crown Castle is one of the best known cell site management companies in the USA. Site management companies offer leasing, permit application, zoning application, and other services related to building or modifying new cell sites which they manage for landowners and/or own themselves.

⁶ "2010 Building Code of New York State", Prepared by International Code Council, Inc. (Washington, D.C.) and New York State Department of State (Albany, New York), Published August 2010.

⁷ ANSI/TIA-222-G-2005, "Structural Standard for Antenna Supporting Structures and Antennas", Published by Telecommunications Industry Association, August 2005, Effective January 1, 2006. ANSI is the American National Standards Institute, and TIA is the Telecommunications Industry Association. TIA is associated with the Electronic Industries Alliance (EIA) in representing the telecommunications industry.

ANSI/TIA-222-G-2005 Standard provide the requirements for building structurally sound cell sites to keep the public safe.

10. The Town of Hempstead General Code, Chapter 142, Section 142-4, Paragraph G-(10) requires that a building permit application include "calculations that the telecommunication facility tower and foundation and attachments, rooftop support structure, water tank structure, and any other supporting structure as proposed to be utilized are designed and are constructed to meet all local, city, state and federal structural requirements for loads, including wind and ice loads."

The ISR Team worked with Town employees to review structural analysis reports submitted to the Town by various carriers as part of the building permit application process for the building or modification of cell sites. These structural analysis reports were the latest filed with the Town for the corresponding cell sites by the various carriers. In our review of 51 structural analysis reports filed with the Town since the ANSI/TIA-222-G-2005 took effect in January of 2006, we noted the following items of concern:

- a. Only 1 of the structural analysis reports reviewed reported calculations or compliance with the ANSI/TIA-222-G-2005 Standard. The other 50 reports included calculations or compliance statements referencing older revisions of the standard, did not specifically reference the ANSI/TIA-222-G-2005 Standard, or did not reference any ANSI standards.
- b. Only 18 of the 51 structural analysis reports (approximately 35%) included calculations to demonstrate compliance with the older revisions of the ANSI/TIA-222-G-2005 Standard. The other 33 reports (approximately 65%) were actually certification letters with either a general statement indicating compliance with

older revisions of the ANSI/TIA-222-G-2005 Standard (except for one), a general statement referencing NYS Building Code, and / or no specific references to any ANSI standard.

- c. 37 of the reports we reviewed were filed with the Town from 2011 through 2013, well after the ANSI/TIA-222-G-2005 Standard took effect in January of 2006.

It was evident from the structural analysis reports reviewed that there was not a demonstrated effort to comply with the ANSI/TIA-222-G-2005 Standard.

11. I emphasize that the ANSI/TIA-222-G-2005 Standard is recognized in the industry as the standard to be used for the building and modification of cell sites. Paragraph 15.4 of the standard states that "existing structures shall be analyzed" whenever there is a "change in type, size; or number of appurtenances such as antennas, transmission lines, platforms, ladders, etc." In response to a question posted to the TIA TR14 Committee⁸ that developed the standard, on February 14, 2007, the TR 14 Committee clarified:

"Previous editions of the standard are considered void. Decisions regarding structures should be made using the latest revision of the standard. The intent was for an engineer to use the latest standard when making decisions regarding the impact of a changed condition."

12. Because the ANSI/TIA-222-G-2005 Standard changed the requirements for wind loading and ice loading in particular, structural analysis report submittals to the Town should reflect an analysis according to this latest standard. The potential for structural failures of cell sites and corresponding impact on public safety should not be minimized. Attached Exhibits B and C are pictures of tower collapses associated with high wind conditions in Oswego, New York

⁸ The TIA TR14 Committee offers a TIA-222-G-2005 FAQ website to assist users of the Standard. The question posted and corresponding answer can be accessed using the following URL:
<http://eetllc.info/TIA-222-GRFQFAQ/index.php?action=artikel&cat=16&id=44&artlang=en>

and North Adams, Massachusetts, respectively. It should be noted that tower collapses can be exacerbated by other circumstances / conditions such as fires. Attached Exhibit D is a picture of a tower fire in Bensalem, Pennsylvania which resulted in the tower leaning over. The tower was eventually taken down. These examples illustrate the need to comply with the latest ANSI/TIA-222-G-2005 Standard, especially the updated wind and ice loading requirements, to ensure cell sites are structurally sound, thereby minimizing the risk to public safety.

STRUCTURAL CONCERN: ENGINEERING BALLAST / SLED MOUNTS

13. Many cell sites in the Town use ballast mounts, which are also referred to as sled mounts, for rooftop installations. A ballast mount consists of a metal frame to which the antennas are mounted, and the ballast used to weigh down / secure the frame to the roof. The ballast usually consists of cinder or concrete blocks. Attached Exhibit E is a picture of a typical ballast mount installation. There are two structural issues that should be monitored for ballast mounted antennas:

- a. The right amount of calculated ballast load needs to be added to the frame to ensure the ballast mount and equipment it holds is secured to the roof.
- b. The supporting roof structure should be able to withstand the loads of the ballast mount and equipment it holds.

14. Generally speaking, Chapter 16 of the NYS Building Code defines the loads⁹ to consider when designing a building to safely support the different loads. ANSI/TIA-222-G-2005 then defines the loads to consider specific to "antenna supporting structures and antennas",

⁹ Section 1602.1 of the NYS Building Code defines loads as "forces or other actions that result from the weight of building materials, occupants and their possessions, environmental effects, differential movement and restrained dimensional changes."

including wind and ice loads. Section 2.5 and 2.6 of ANSI/TIA-222-G-2005 clarify that dead loads¹⁰ should include "antennas, antenna mounts, transmission lines, conduits, lighting equipment, climbing devices, platforms, signs, anti-climbing devices, etc."

15. As part of our review of structural analysis reports (see Paragraph 10 above), the ISR Team was provided seven (7) structural analysis reports submitted to the Town by various carriers for ballast mounted rooftop antenna installations at 7 different sites. 6 of the 7 structural analysis reports provided calculations for wind loading and dead loads that need to be supported by the building / rooftop structure. However, all 7 reports submitted between 2011 and 2012 were not conducted in accordance with the ANSI/TIA-222-G-2005 Standard. They reference the previous revision of the standard, ANSI/TIA/EIA-222-F,¹¹ which had different requirements for wind and ice loading. In fact, **none of the 7 reports** indicated that ice loading was considered as part of their analysis.

16. The results of 4 of the 7 structural analysis reports submitted to the Town indicated that the existing ballast **was not sufficient to secure the ballast mount and the equipment it supports to the rooftop**. Recommendations were made regarding additional ballast and/or modification to the ballast mount needed to secure the mount to the rooftop. Since the calculations were in accordance with the older ANSI/TIA/EIA-222-F Standard, with different methods of calculating wind and ice loading, it is possible that the ballast requirements have

¹⁰ Section of the NYS Building Code defines dead loads as "the weight of materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding and other similarly incorporated architectural and structural items, and the weight of fixed service equipment, such as cranes, plumbing stacks and risers, electrical feeders, heating, ventilating and air-conditioning systems and fire sprinkler systems."

¹¹ ANSI/TIA/EIA-222-F-1996, "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures", Published by Telecommunications Industry Association, Published June 1996.

changed. Furthermore, the Town had received no follow-up reports or certification letters indicating that the additional ballast and/or modification the ballast mount were completed to comply with the ANSI/TIA/EIA-222-F Standard. It is a concern that these ballast mount installations do not comply with the ANSI/TIA/EIA-222-G-2005 Standard, have not specifically considered ice loading, and needed additional ballast to secure the mounts to the rooftops.

17. The ice and wind loading calculations determine additional loads that must be supported by the roof and overall building structure. Though all 7 structural analysis reports for the ballast mounted antennas did consider rooftop loading as part of their calculations, they have not considered the wind and ice loading in accordance with the ANSI/TIA-222-G-2005 Standard, which may require the rooftop to support additional loads. To be clear, this is a separate but related issued regarding ballast mount rooftop installations. Ballast is required to secure the ballast mount to the rooftop, but the rooftop must support the loads associated with the ballast. Therefore, there is a concern of whether or not the rooftops can support the additional loads as calculated using the ANSI/TIA-222-G-2005 Standard.

18. Of particular concern regarding ballast mounted antennas is the additional load on the rooftop, especially in the event of a fire. The additional load on the rooftop could cause a roof collapse in the area where the ballast mount load is concentrated. The following cautionary statement appears in an article in a magazine titled Fire Engineering:¹²

¹² Joseph Viscuso, "Safe Operations Near Roof Cellular Base Stations", Fire Engineering Magazine, March 1, 2008. The article is available online at the following URL:
<http://www.fireengineering.com/articles/print/volume161/issue3/features/safeoperationsnearroofcellularbasestations.html>

"A ballast roof mount system creates a concentrated load on the roof; this is a load that is applied to a small area of the roof. If the roof structure below the ballast mount is under attack by fire, the weight of the ballast mount may cause premature collapse."

19. Attached Exhibit F is a picture of ballast that was left on the rooftop at 1975 Linden Boulevard in Elmont. This is unnecessary dead load on the rooftop. We also do not know if this ballast was intended to secure any of the ballast mounts to the rooftop. A 2012 structural analysis report for the Sprint ballast mounts indicates additional ballast was needed to secure their mounts to the rooftop.

20. To summarize, the ANSI/TIA-222-G-2005 Standard was not used for the structural analysis reports we reviewed for ballast mount rooftop antenna installations. Load calculations according to the latest version of the standard are required not only to determine the correct amount of ballast needed to secure the ballast mounted equipment to the rooftop, but also to ensure the loads of the ballast mount installation can be supported by the rooftop. Not having analyses based on the ANSI/TIA-222-G-2005 Standard is a concern, especially in the event of a fire, since the rooftop may not be able to support the additional loads required to secure the ballast mounts to the rooftop.

ELECTRICAL CONCERN: PROPER GROUNDING OF COAXIAL CABLES

21. Coaxial cable is used to connect the cell site antennas to the base station equipment. To safeguard against electrocution and fire hazards, the coaxial cable of cell sites must be properly grounded. The proper grounding of cell sites is generally covered by Articles 250 (grounding bus

bar), 810 (base station equipment), and 820 (coaxial cable) of the NFPA 70, NEC, 2011 Edition.¹³

Proper grounding provides a path of low resistance to lightning, in essence diverting the energy associated with lightning towards the electrical ground to which the ground bus bar is connected. When coaxial cable is properly grounded, the electrical energy (current) of a lightning strike would go to electrical ground instead of the electronic equipment of the base station.

22. Though the NEC covers the proper grounding of base station equipment and antenna supporting structures (pipe mounts and ballast mounts), the ISR Team focused on the proper grounding of the coaxial cable to ground bus bars during the audits of 27 cell sites. We focused on the proper grounding of coaxial cable to ground bus bars because the Senior RF Engineers on the team were aware that theft of equipment and cable containing copper is a relatively common occurrence. In accordance with the NEC, coaxial cable is usually grounded to a ground bus bar using a bonding conductor, as detailed in the attached Exhibit G. Unlike the picture in Exhibit G, many ground bus bars are made of copper which can be sold as scrap metal.

23. At 4 of the 27 cell sites we audited (approximately 15%), it was obvious the ground bus bars were missing and probably stolen, as can be seen in attached Exhibits H (2545 Hempstead Turnpike, East Meadow) and I (1975 Linden Boulevard, Elmont). In the event of a lightning strike at a location with a missing ground bus bar, the current would not be directed to ground (the purpose of the grounding bus bar) and could lead to arcing (jumping) to another metal object, sparking, and/or fire. Lightning is both a source of extreme temperature and high electrical currents. Attached Exhibits J and K are examples of electrical damage that can occur when

¹³ National Fire Protection Association (NFPA) 70, National Electric Code (NEC), 2011 Edition, Prepared by the National Electric Code Committee, Issued by Standards Council August 5, 2010, Effective August 25, 2010.

lightning reaches electrical equipment, such as that of cell site base stations, with the potential of starting a fire.

24. I have expressed a concern to the Town that the theft of ground bus bars is a random but increasingly common occurrence. The problem has generated new product lines for major suppliers of materials and equipment to the RF industry like Tessco, RFS, and Commscope. Solutions include galvanized steel ground bus bars, aluminum copper clad steel grounding cable, and aluminum coaxial cable. However, these products will not solve the problem until they are widely deployed. In the meantime, as we found during our cell site audits, there is a risk of electrocution as well as electrical and fire damage, at cell sites where ground bus bars or bonding conductors have been stolen.

25. I do not know how long the ground bus bars were missing at the cell sites we audited. It may be an indication that RF engineers and field technicians are not visiting cell sites on a regular basis, or not trained to take advantage of their visits to look for grounding issues as we did. In any event, the lack of proper grounding presents a real risk of damage to life and property.

COMPLIANCE WITH FCC OET BULLETIN 65

26. FCC OET Bulletin 65, attached as Exhibit L and referenced in footnote 2, page 3 above, establishes the guidelines for evaluating human exposure to RF emissions. FCC OET Bulletin 65 provides predictive methods and formulas to calculate emissions, methods for the measurement of RF emissions, and most importantly guidelines on limiting exposure to RF emissions. FCC OET Bulletin 65 is a fairly comprehensive document, and we evaluated many aspects of compliance with the guidelines during our audit of 27 cell sites. In this affidavit, we are

providing comments regarding the compliance to FCC OET Bulletin 65 for 47 rooftop sites for which MPE Reports were submitted to the Town by various carriers as part of the building permit application process for the building or modification of cell sites. We are focusing on rooftop installations because FCC OET Bulletin 65 excludes cell sites, where the lowest point of any antenna is more than 10 meters (approximately 33 feet) above ground level, from routine evaluations for compliance.

27. Here are some key points to consider with regards to compliance with the FCC OET Bulletin 65 guidelines:

- a. The RF exposure and emissions limits are classified for two different conditions:
 - i. Occupational or Controlled exposure where "persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control."
 - ii. General Population or Uncontrolled exposure where "the general public is exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure."
- b. The maximum RF emissions limit, in terms of power density, is five times higher for occupational exposure versus general population exposure. However, for the purposes of compliance evaluation (maximum permissible exposure or MPE), the occupational RF emissions limit needs to be time averaged over a maximum 6 minute

evaluation period, whereas the evaluation period is a maximum of 30 minutes for the general population emissions limit.

- c. In order to apply the Occupational or Controlled MPE limits, FCC OET Bulletin 65 suggests that access be restricted or controlled, specifically by the use of fences, warning signs, and/or locking out unauthorized persons in areas. More importantly, to comply with Occupational MPE limits, exposure to higher RF emissions should be limited to no more than 6 minutes, assuming continuous exposure to the higher RF emissions.
- d. Section 2 of FCC OET Bulletin 65 defines different methods and formulas that can be used to calculate / predict the RF emissions in different environments (on the ground or on a rooftop, near an antenna or farther away from an antenna, etc.). However, it is recognized that on multiple transmitter sites (multiple carriers at the same site) it may not be practical to calculate / predict RF emissions if the technical information for each carrier is not available. Specifically, Section 3 defines the methods for measuring RF emissions with instrumentation, stating that "actual measurements of the RF field may be necessary to determine whether there is a potential for human exposure in excess of the MPE limits specified by the FCC."
- e. RoofView is commercially available software that uses a cylindrical model developed by Richard Tell¹⁴ which is more accurate for predicting MPE on rooftops, including situations where there are multiple carriers on the rooftop.

¹⁴ Richard Tell Associates, Inc. developed the RoofView software. His work is referenced and recognized in FCC OET Bulletin 65. His experience regarding RF safety is well documented in attached Exhibit M.

28. Of the 47 MPE Reports for rooftop installations that we reviewed, 14 reports (approximately 30%) indicated that the cell sites were compliant with FCC OET Bulletin 65 though they did not include a rooftop analysis. The methodology and calculations were for a General Population ground/street level analysis, but did not include any calculations or measurements for the actual rooftop. The calculated street level emissions were from 0 feet (building façade) to hundreds of feet away from the building. Therefore, these MPE Reports did not address MPE compliance on the rooftop though it was claimed that the cell site was compliant with FCC OET Bulletin 65.

29. Exhibit N is an example of an MPE Report that did not complete a rooftop MPE analysis but claimed compliance with FCC OET Bulletin 65. The report was submitted by Pinnacle Telecom Group for the Verizon cell site at 2545 Hempstead Turnpike in East Meadow, New York. Exhibit O is a picture of the building and the rooftop cell site. The latest MPE Reports submitted by AT&T and T-Mobile included RoofView predictions that the Occupational MPE limits are exceeded at certain areas on the rooftop. Furthermore, we visited this cell site with a Radman XT¹⁵ personal safety monitor, and the Radman XT confirmed that RF emissions were exceeding 100% of the MPE Occupational limits in areas that would be accessible to workers on the rooftops.

30. In addition to reports submitted that did not evaluate RF emissions on the rooftops, another 8 of the 47 reports (approximately 17%) that utilized RoofView predicted RF emissions exceeding the Occupational MPE limits. However, the reports incorrectly concluded that the cell

¹⁵ The Radman XT is a personal safety monitor manufactured by Narda Safety Test Solutions in Germany. Narda Safety Test Solutions also manufactures instruments that can be used to measure and record power density, magnetic field strengths, and electric field strengths to determine MPE compliance. At Nextel and Sprint-Nextel, we used Narda personal safety monitors and measuring instruments, and they are recognized in the RF industry.

sites complied with FCC OET Bulletin 65, which requires some action to limit exposure any time RF emissions are found to be noncompliant. 7 of these 8 reports did indicate some follow-up action (mostly posting signs) was needed to comply with FCC OET Bulletin 65, but the evidence presented in the reports did not support the conclusions that the sites were compliant, because further action was needed for compliance. 2 of the 8 reports noted lower and compliant RF emissions predictions in their conclusions, though the RoofView predictions indicated otherwise. It should be noted that we visited 4 of these sites that predicted RF emissions exceeding the Occupational MPE limits with a Radman XT personal safety monitor, and the Radman XT confirmed that RF emissions were exceeding 100% of the MPE limits for Occupational exposure in areas that would be accessible to workers on the rooftops.

31. Regarding methods of limiting RF Exposure, OET Bulletin 65 states:

“Although restricting access may be the simplest and most cost-effective solution for reducing public exposure, other methods are also available. Such methods may be relevant for reducing exposure for both the general public and for workers. For example, modifications to antennas, elevating antennas on roof-top installations or incorporation of appropriate shielding can reduce RF fields in locations accessible to the public or to workers.”

I have indicated my concern to the Town that restricting access and/or posting signs on rooftops where Occupational RF emissions limits are exceeded may not be sufficient to limit exposure time and hence comply with Occupational MPE limits. There is no evidence in the reports we reviewed that consideration was given to other methods for limiting exposure beyond restricting access and posting signage.

32. As an example where restricting access and posting signs may not be the best approach for limiting exposure time, attached Exhibit P is a picture taken at 2631 Merrick Road in Bellmore. There was an RF warning sign on the door to access the rooftop, but the door was not locked and no signs were posted on visible areas in front of the antennas. We had free access to the rooftop, which means it should be considered a General Population environment. The yellow chain link may have been an attempt to limit access but it did not cordon off any area and you can easily walk around it. Any worker on the rooftop without proper RF training could be exposed to levels above the MPE Occupational limits. Available MPE Reports from the carriers as well as our Radman XT predicted/indicated high RF emissions in front of the antennas shown in Exhibit P. More concerning is the fact that one MPE Report for this site predicted RF emissions at 871.10% of the General Population MPE limit.

33. In a Wall Street Journal Report published October 2, 2014,¹⁶ the article stated that Richard Tell (see footnote 14 on Page 16) approximates he found 10% of 1,000 cell sites (approximately 100) were not fully compliant with FCC OET Bulletin 65. As the article indicates, non-compliance is of particular concern for the health of rooftop workers. In an April 4, 2014 letter to the FCC¹⁷ attached in Exhibit Q, Edwin D. Hill of the IBEW expressed his concerns regarding the exposure of workers to RF emissions on rooftops and other locations, many of whom who are not trained regarding RF safety.

34. To summarize, our review of 47 rooftop MPE Reports submitted to the Town found that 30% of the reports did not use the correct methodology to determine if the rooftops were

¹⁶ Ianthe Jeanne Dugan and Ryan Knutson, "Cellphone Boom Spurs Antenna-Safety Worries", The Wall Street Journal, October 2, 2014.

¹⁷ Edwin D. Hill, International Brotherhood of Electrical Workers (IBEW), Comment Regarding Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields, ET Docket No. 03-137, Letter to Marlene H. Dortch, Secretary, FCC, April 4, 2014. The IBEW is a labor union representing workers in the electrical industry, such as electricians and linemen.

compliant with FCC OET Bulletin 65. Another 17% of the reports did predict the Occupational MPE RF emissions limits could be exceeded, but I question whether the most effective methods to limit exposure are being taken. Exceeding the Occupational MPE limits without effective methods to limit exposure is of particular concern for the health and safety of rooftop workers.

35. Additional discussion and documentation of MPE compliance issues are contained in my Supplemental Declaration of Eduardo Orellana dated February 25, 2015 which will be filed under seal with the United States District Court for the Eastern District of New York in Verizon Wireless et al v Town of Hempstead, Dkt. 10-cv-4997 (EDNY).

CONCLUSIONS

36. The ISR Team conducted cell site audits, reviews of structural analyses, and review of MPE Reports in an effort to understand safety concerns at cell sites in the Town of Hempstead. We have detailed our concerns to the Town, which we summarize here:

- a. Structural analyses reports submitted to the Town do not demonstrate an effort to comply with the latest ANSI/TIA-222-G-2005 Standard, and the new wind and ice loading requirements defined within. Only 1 report refers to ANSI/TIA-222-G-2005, and only 35% of the reports submitted included calculations as required by the Town of Hempstead General Code. Of particular concern are ballast mount rooftop antenna installations which may require more ballast to secure the mounts to the rooftop and should be properly engineered to ensure the rooftop can support the additional loads. Compliance with the ANSI/TIA-222-G-2005 Standard ensures the best effort to

- construct structurally sound cell sites and mitigate any risks to public safety and property damage in the event of a structural failure.
- b. During our cells site audits we found some sites with coaxial cable that was not properly grounded because the ground bus bars were missing. Improperly grounded coaxial cable presents an electrical and fire hazard to the public, electrical equipment, and property, especially in the event of lightning strikes. The fact that we were able to find 4 cell sites that were missing ground bus bars as part of a random selection of cell sites to audit indicates the problem may be growing, as recognized by the industry which is now developing solutions to prevent theft of copper RF materials and components. Though not a solution to the problem, more routine visits to the cell sites by carrier personnel can at least help to identify cell sites that need ground bus bars installed after theft.
 - c. Exposure to RF emissions above the established Occupational limits in FCC OET Bulletin 65 poses a safety and health risk to rooftop workers in particular. Our review of the MPE Reports indicated the wrong methodology is sometimes used to predict Occupational MPE compliance on rooftops. Furthermore, when predictions indicate Occupational MPE limits are exceeded, the most common suggestions in the reports to limit exposure are to restrict access and post signage. While cost-effective, other solutions should be considered.

37. In a limited sampling of cell site audits and documents to review, we found safety hazards and potential safety hazards that warrant concern and follow-up. In the case of 2545 Hempstead Turnpike and 1975 Linden Boulevard, we found multiple conditions (improper

grounding, ballast mounts requiring additional ballast, and high RF emissions readings) that warrant concern.

38. I state under penalty of perjury that the foregoing is true and correct. Executed on February 25, 2015.


EDUARDO ORELLANA

EXHIBIT A:
CURRICULUM VITAE

Integrated Strategic Resources,

a Certified Woman Owned Disadvantaged-Business Enterprise

Systems Integration – Communications (RF-Wireless) & Network Applications – Electronic Security – Rail Transit Operations/Analysis

Eduardo Orellana

Director Communications Wireless/RF Technologies

Ed has over 20 years of engineering and management experience, with more than 11 years experience in systems integration, technical design, deployment, and management of teams for complex communications network projects throughout the New York Area. In recent projects Ed served as Project Manager for the NYCT Bus Radio Interim Upgrade Project, Project Manager and Senior Communications Engineer for Denver Transit Partners' WiMax based Positive Train Control System. Earlier, Ed served as a Senior Communications and Wireless/Radio Frequency Engineer on the NYCT Chambers Street Electronic Security System (ESS) project authoring one of the required Operations and Maintenance (O&M) Manuals and corresponding training course. Ed had the responsibility of driving the overall O&M Manual and training processes, including development, submittal, and approval. He participated in system implementation, integration, testing and commissioning of the numerous communications elements of this integrated ESS, in particular the access control and laser intrusion detection subsystems.

Ed has worked in the forefront of communications technology, field directing operations and engineering personnel and providing oversight for design and performance optimization of iDEN, CDMA, and UMTS technology networks and UPS systems. Ed worked with site acquisition and construction departments for the build of more than 150 iDEN and CDMA cell sites, more than 100 of which he personally designed. Ed restructured engineering teams and hired contractors to successfully manage the design and deployment of 80+ cell sites.

Early in his career, Ed was Underwriters Laboratories' Regional Leader for International Registration Programs in Latin America. In this position he led no fewer than 19 worldwide Inspection Centers for UL's International Inspection Services (IIS) Department. He directed Quality Registration Services in Latin America, adhering to ISO and QS 9000 standards.

Education **Master of Science, Electrical Engineering., Polytechnic University**
Bachelor of Science Electrical Engineering, Manhattan College

Work Experience

Bus Radio Interim Upgrade Project, New York City Transit, New York, NY. Ed recently served as Project Manager for the integration of new Uninterruptable Power Supplies

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(UPS), microwave backhauls, and new UHF simulcast radio network equipment as part of an upgrade of NYCT's existing bus radio system. The project is upgrading the equipment located at four base station sites and the command center. He also managed the relationship with NYCT by ensuring on-time delivery of equipment cut sheets, rack and layout drawings, methods of procedures, test procedures, schedule updates, and other key deliverables. Ed and his team coordinated multi-disciplinary surveys to identify locations of equipment removal and installation, to identify power feeds and distribution, to verify planned work complies with NYCT contract specifications and to generally plan the order of delivery, installation, and integration. Ed worked with vendors as an engineering lead in the development of methods of procedure (MOP) and acceptance test plans (ATP). The Bus Radio Project work consisted of upgrade, installation, optimization, integration, testing and cutover from old to new equipment. Upgrade included base station repeaters, microwave link radio equipment, central site controllers, channel bank electronic equipment and alarm monitoring equipment.

Denver – Positive Train Control (PTC) - FasTracks Commuter Rail, Regional Transit District (RTD), Denver, Colorado. Denver Transit Partners is a concessionaire to RTD and is responsible to design, build, operate and maintain the FasTracks commuter rail system. Nomad Digital, a subcontractor to the concessionaire, is responsible to design and implement the communications backbone for Positive Train Control (PTC). Nomad Digital has engaged ISR to assist with the design of the communications system, including but not limited to placement of the WiMAX base stations and antenna configurations along the right-of-way. Ed is ISR's project manager and senior communications engineer in this effort, supervising other ISR engineers in various aspects of the PTC base station design using Mentum Planet propagation software, and working on-site with Nomad Digital on field surveys and testing to further develop and verify the designs.

Electronic Security for Chambers Street Station Complex, MTA Capital Construction (MTACC) and New York City Transit (NYCT) – New York, NY. Ed served as a Senior Communications and Wireless/Radio Frequency Engineer on the NYCT Chambers Street Electronic Security System (ESS) project. At the outset of this project Ed worked within the team to identify all required tests and inspections, and associated submittals, and is helping develop comprehensive project test plans and test procedures. Ed interfaced with equipment vendors to obtain the latest operations manuals, specifications, and CAD drawings needed to review different aspects of systems integration and testing. In addition to authoring one of the required Operations and Maintenance (O&M) Manuals and corresponding training course, Ed had the responsibility of driving the overall O&M Manual and training processes, including development, submittal, and approval.

He participated in system implementation, integration, testing and commissioning of the numerous communications elements of this integrated ESS, in particular the access

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control and laser intrusion detection subsystems. The project included the introduction of approximately 70 cameras in the mezzanine and platform areas of the Chambers Street and Brooklyn Bridge stations, an access control system to monitor authorized and unauthorized access to tunnel ingress routes, installation of a laser intrusion detection system to cover the tunnel ingress routes, and installation of system and network control equipment to support monitoring and control of these systems from the Security Operations Center.

ASES II Support Services, NJ Transit. Ed is assigned as a Radio Frequency Communications engineer on the engineering team supporting New Jersey Transit (NJT) on the Advanced Speed Enforcement System (ASES II) project. At the outset of this project Ed has the primary responsibility on the team for mapping available RF spectrum in the different frequency bands required to support implementation of the Positive Train Control (PTC) on NJT's commuter rail lines. This is part of a larger effort of spectrum acquisition support to NJT for ASES II. As the project continues, Ed will assist NJT with the design-build contractor for ASES II on, among other things, ensuring interoperability with the available spectrum and interoperability of ASES II with PTC systems deployed by Amtrak, MTA Metro-North Railroad, SEPTA, and freight railroads. At the request of NJT and the engineering team, Ed has authored reports regarding the expected coverage of PTC transmitters, the options for serial communications over long distances, and the use of microwave links in the PTC backhaul.

Radio Frequency (RF) Testimony for the Town of Hempstead, New York. Ed provided RF testimony as an expert regarding the design and performance of cell phone towers for different cell phone technologies, including iDEN, CDMA, UMTS, and OFDM. RF testimony explained how cell phone towers and cell phones operate for the different technologies.

Second Avenue Subway, New York City Transit, New York, NY. Ed first worked on the preliminary redesign of the Software House access control system to dimension it for the large amount of card readers, horn/strobes, door sensors, etc. at the 63 St. Station. He then evaluated equipment cut sheets to verify equipment complied with the contract specifications, and reported discrepancies to System Integration Engineer. Further duties include developing the initial training matrix for the project to classify training and assess impact of training on the overall schedule. The Second Avenue subway systems integration first phase project includes managing the design, implementation, testing and training of the new CCTV system, as well as the Access Control/Intrusion Detection systems. Additionally, scope includes managing the computer-based dispatch system, Solar Uptime station clocks and overall WAN/LAN Networks.

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Sprint-Nextel / Ericsson Services, Inc. - Garden City, New York. RF Engineer III / Senior RF Engineer. Ed directed all aspects of performance optimization activities for the Sprint-Nextel CDMA network on Long Island. Audited base station cell sites to ensure they are optimized for RF coverage and capacity relief, collecting and analyzing drive test data to recommend site modifications as needed. Monitored performance of 100-150 sites, analyzing statistics and implementing crucial parameter/antenna configuration adjustments. Worked with Field Operations to diagnose and repair customer-impacting hardware failures. Reviewed and approved in-building/DAS systems designs.

iDEN RF Manager. Forged and provided oversight for design and performance optimization, expertly directing teams of up to 12 engineers and all aspects of resource optimization and process improvement. Expedited daily operations including workload assignment and management, staff training and supervision, and performance improvement initiatives. Hired, mentored, trained, and evaluated all employees. Led and engaged engineers in identifying and correcting problems, strengthening productivity, overhauling and improving operating processes and systems, and resolving quality issues. Crafted and delivered high-impact presentations regarding network performance for Internal Departments, and the government clients.

Nextel Flarion Broadband (4G) Trial - Raleigh, North Carolina. RF Engineer. Ed was hand-picked to represent Nextel's Northeast Region in Flarion wireless broadband trial. He met the challenge of developing and monitoring validation testing procedures. Ed drove cross-functional coordination of engineers and field test teams in executing tests and analyses. In an award-winning effort, he conducted 1900 MHz RF propagation studies utilizing computer simulations (Wizard) to recommend antenna configuration changes and subsequently improve RF coverage, data throughput, and overall performance. Ed developed maps to deliver comprehensive test results to Sales and Marketing.

Among his specific accomplishments at Sprint-Nextel/Ericsson:

- Restructured engineering team and hired contractors to successfully manage the design of 80+ sites, with 40 currently on-air.
- Pioneered and implemented innovative plan to restore T1 service for 10 cell sites following the 11 September 2001 attack; utilized 18 GHz microwave as a T1 backhaul to restore sites delivering quality coverage to emergency responders within 10 days.
- Designed 2 sites to provide coverage over the water in New York Harbor, coordinating with frequency planning team to ensure minimal interference and dramatically improve our Staten Island Ferry service.
- Deployed statistical analysis and trending methodologies to correlate technology-

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specific parameter changes and the corresponding impact on network performance.

- Earned reputation as top performer, achieving Nextel Circle of Excellence Award in 2002, Broadband Trial Award in 2004, and Excellence Award in 2007.

Underwriters Laboratories, Inc. - Melville, New York. UL is a not-for-profit organization providing Product Safety Certification and Quality System Registration Services in the U.S. and internationally. He was UL's Regional Leader, International Registration Programs. In this position Ed led no fewer than 19 worldwide Inspection Centers for UL's International Inspection Services (IIS) Department. Directed Quality Registration Services in Latin America, adhering to ISO and QS 9000 standards. Ed coordinated training and qualification of local auditors, liaising with corporate program managers to ensure compliance with auditing and Registrar accreditation standards.

Training

- eXpert Wireless Solutions/Wireless 102 & 103
- iDEN Systems School
- iDEN Packet Data Network/Technology Prediction and Trending
- Flarion Flash-OFDM Training Antennas, Propagation, and Fading: Theory and Practice
- Lucent CDMA RF 100 & 200 Course
- Lucent PCS CDMA RF Performance Engineering
- Lucent 1xEV-DO RF Design Engineering and Call Processing

Affiliations

- Society of Hispanic Professional Engineers
- Institute of Electrical and Electronics Engineers (IEEE)

Employment History

Integrated Strategic Resources	2010 - present
Ericsson Services, Inc., formerly Sprint-Nextel	2009 - 2010
Sprint-Nextel	1999 - 2009
Underwriters Laboratories, Inc.	1991 - 1999

EXHIBIT B:
TOWER COLLAPSE IN HIGH WIND CONDITIONS
OSWEGO, NEW YORK

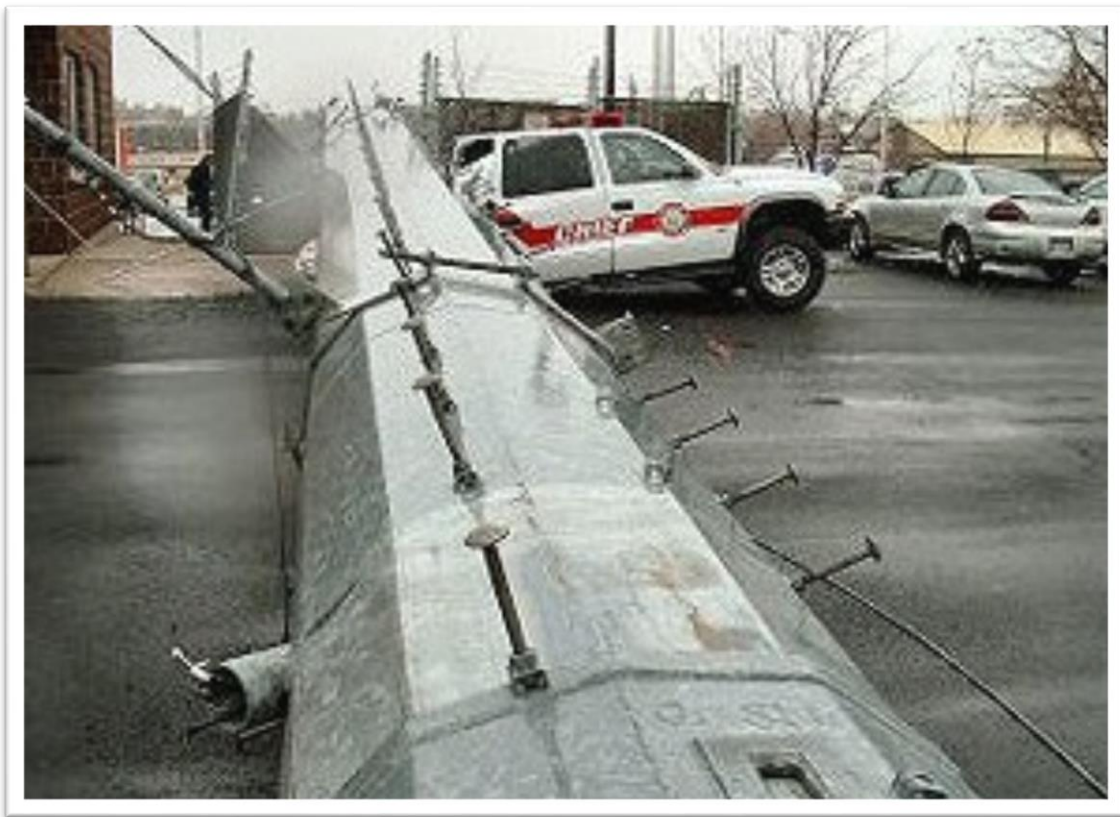


EXHIBIT C:
TOWER COLLAPSE IN HIGH WIND CONDITIONS
NORTH ADAMS, MASSACHUSETTS



EXHIBIT D:

TOWER LEANING DUE TO FIRE – BENSALEM, PENNSYLVANIA

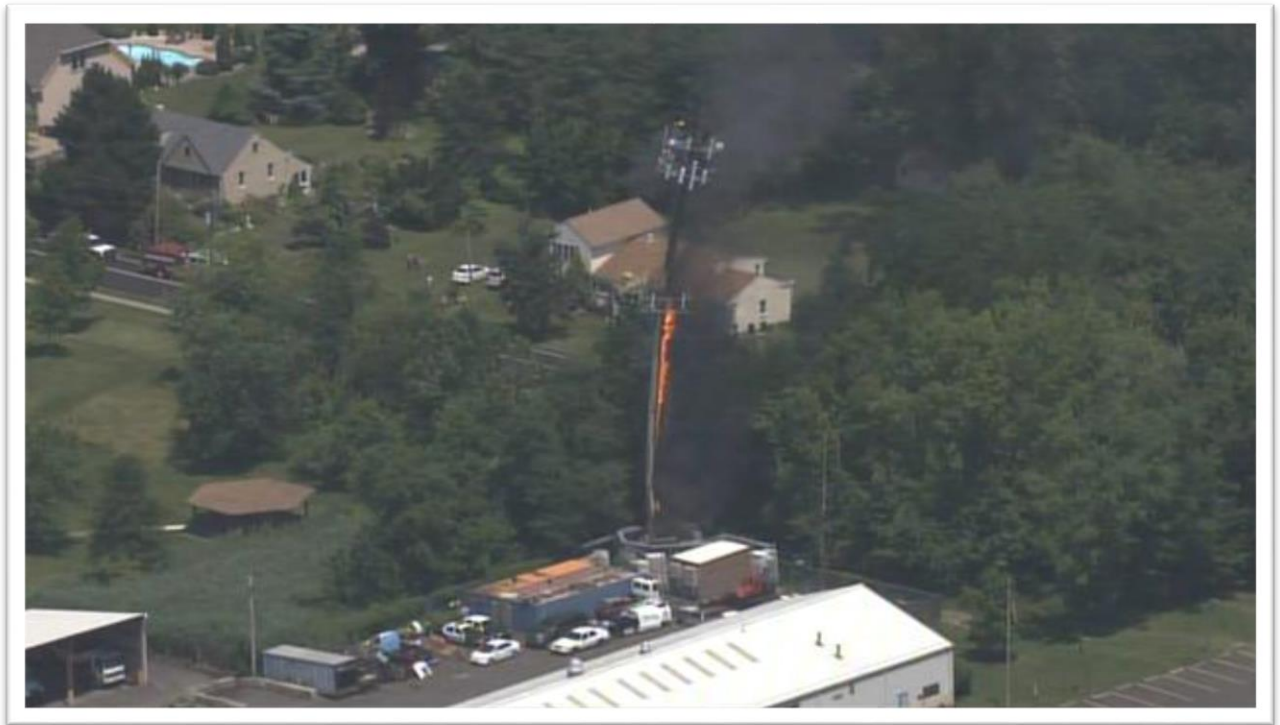


EXHIBIT E:
TYPICAL BALLAST MOUNTED ANTENNAS



EXHIBIT F:
ABANDONED BALLAST
1975 LINDEN BOULEVARD, ELMONT, NY



EXHIBIT G:
PROPER GROUNDING OF COAXIAL CABLE

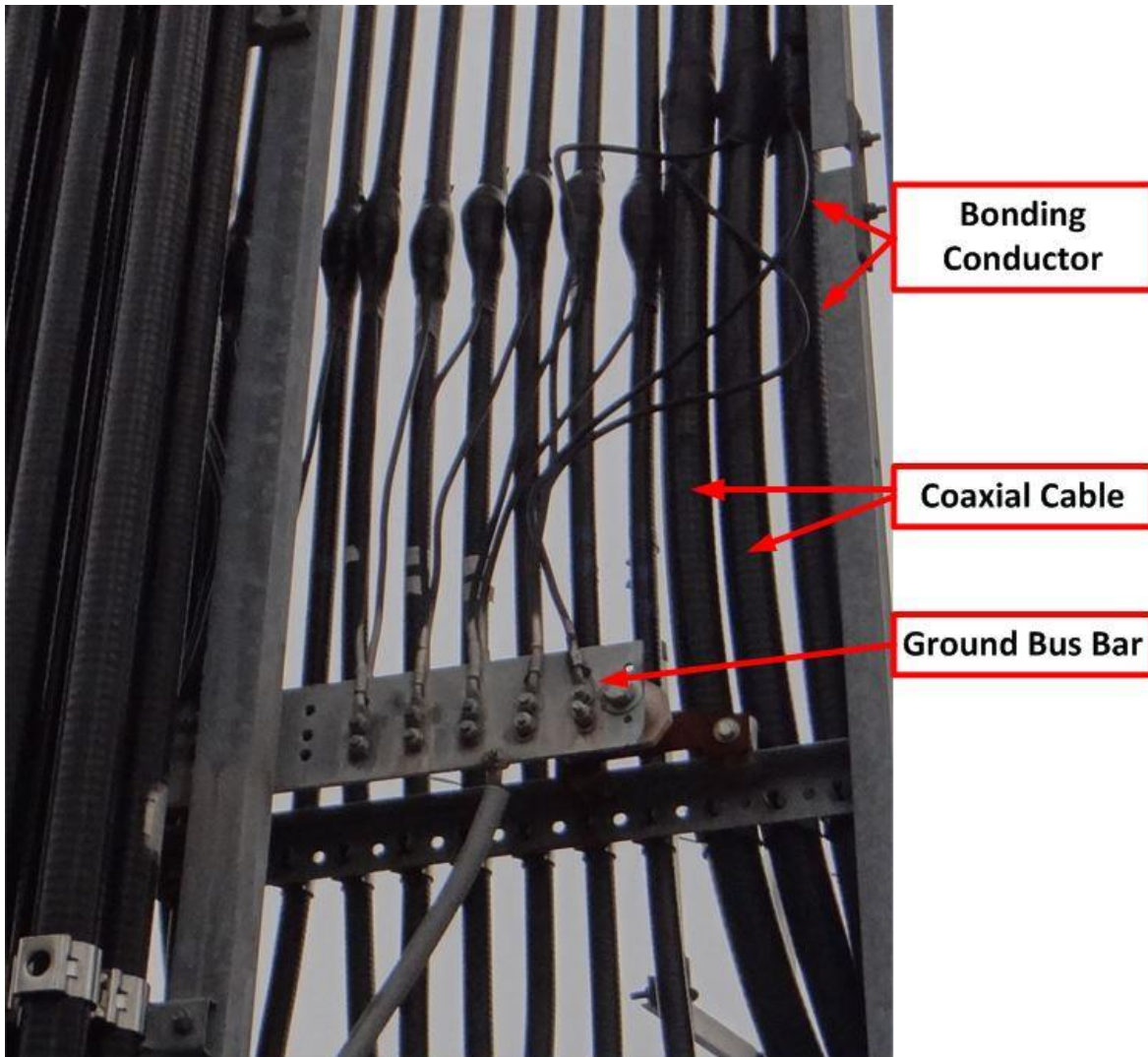


EXHIBIT H:
MISSING GROUND BUS BAR
2545 HEMPSTEAD TURNPIKE, EAST MEADOW, NY

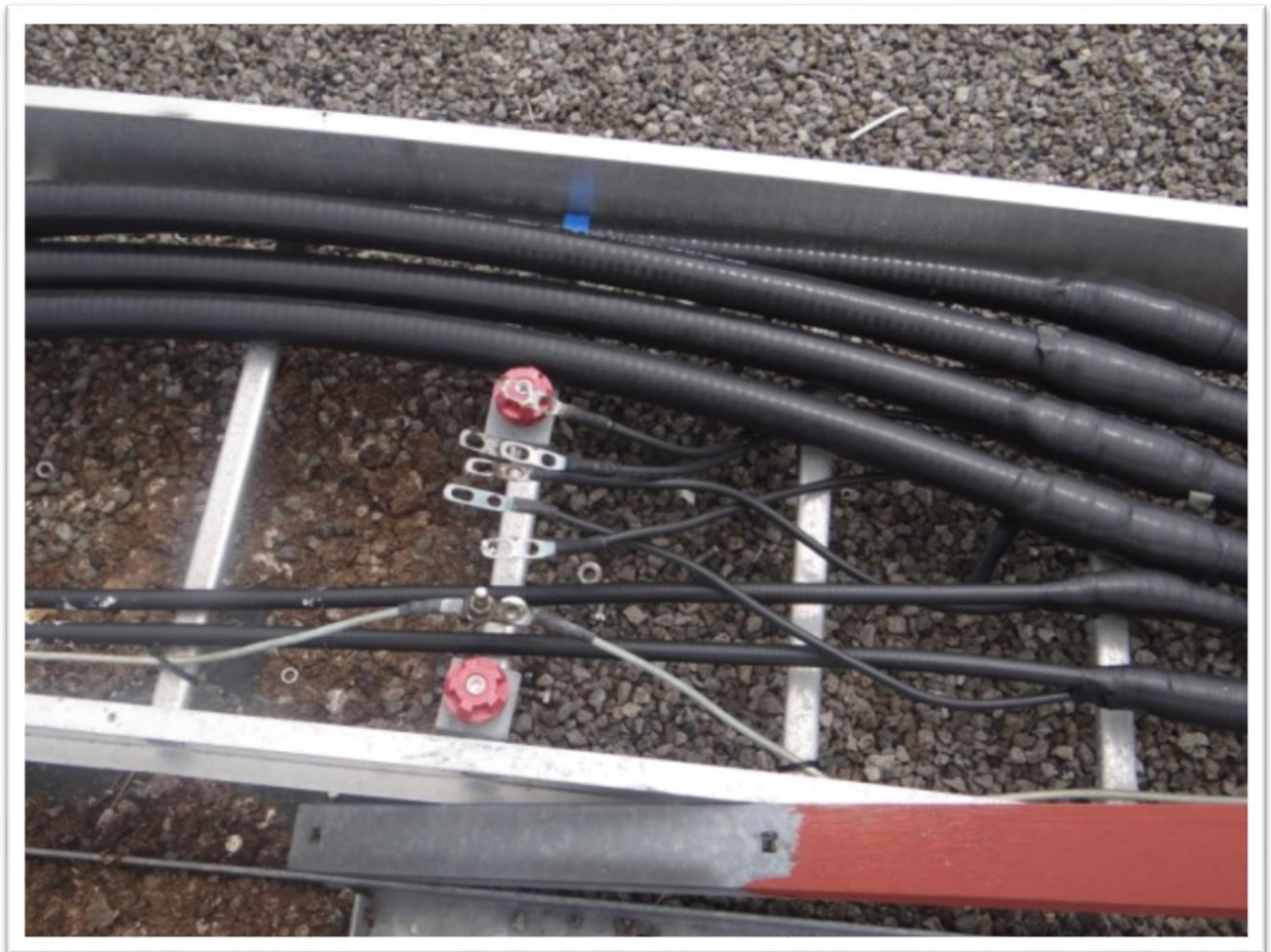


EXHIBIT I:
MISSING GROUND BUS BAR
1975 LINDEN BOULEVARD, ELMONT, NY

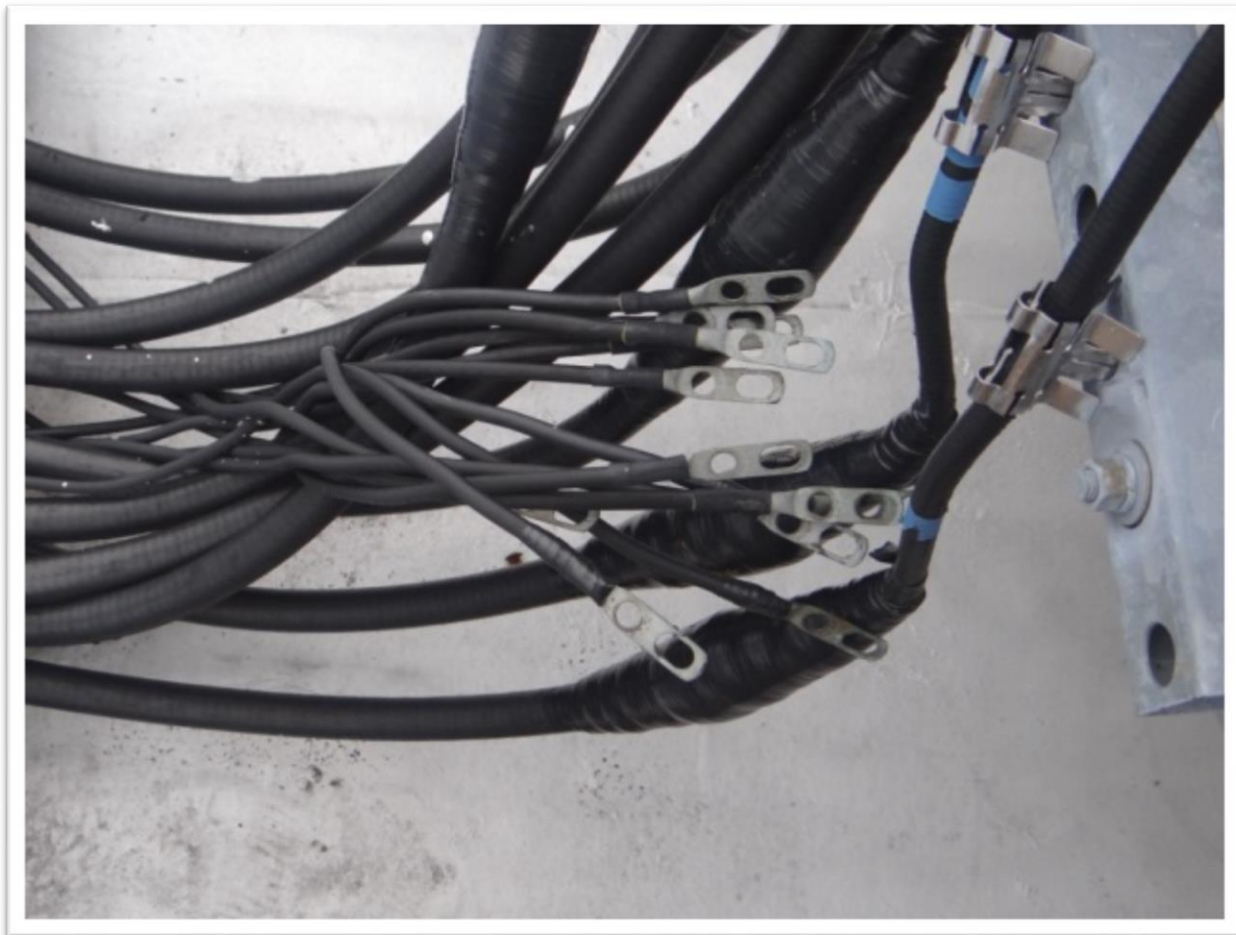


EXHIBIT J:
EXAMPLE OF ELECTRICAL DAMAGE TO EQUIPMENT ATTRIBUTED
TO LIGHTNING STRIKE



EXHIBIT K:
EXAMPLE OF ELECTRICAL DAMAGE TO EQUIPMENT ATTRIBUTED
TO LIGHTNING STRIKE

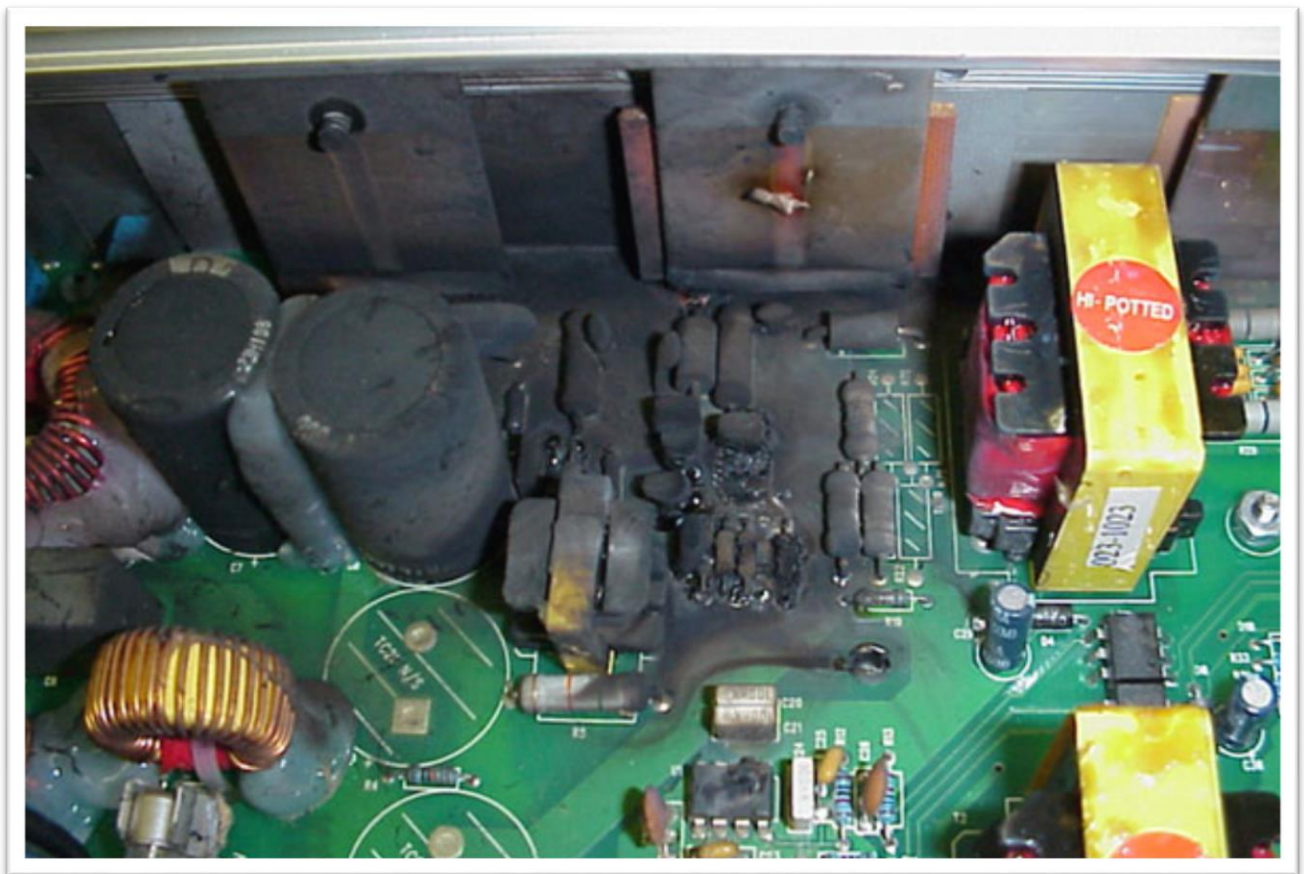


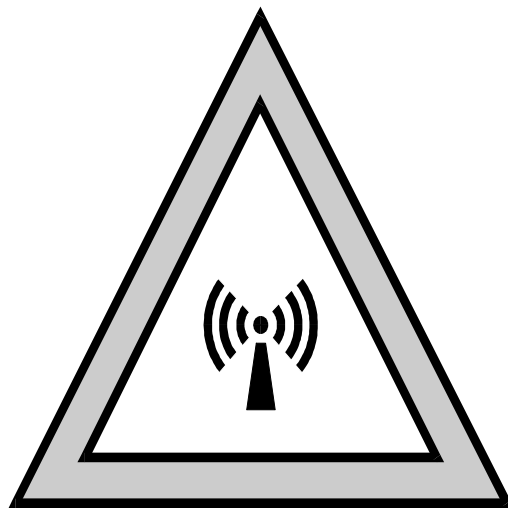
EXHIBIT L:

FCC OET BULLETIN 65



***Federal Communications Commission
Office of Engineering & Technology***

Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields



OET Bulletin 65

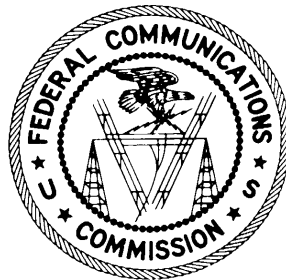
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**Evaluating Compliance with FCC
Guidelines for Human Exposure
to Radiofrequency Electromagnetic Fields**

**OET BULLETIN 65
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August 1997



AUTHORS

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Federal Communications Commission
Washington, D.C. 20554**

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NOTE: Mention of commercial products does not constitute endorsement by the Federal Communications Commission or by the authors.

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Cellular Telecommunications Industry Association
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INTRODUCTION

This revised OET Bulletin 65 has been prepared to provide assistance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to radiofrequency (RF) fields adopted by the Federal Communications Commission (FCC). The bulletin offers guidelines and suggestions for evaluating compliance. ***However, it is not intended to establish mandatory procedures, and other methods and procedures may be acceptable if based on sound engineering practice.***

In 1996, the FCC adopted new guidelines and procedures for evaluating environmental effects of RF emissions. The new guidelines incorporate two tiers of exposure limits based on whether exposure occurs in an occupational or "controlled" situation or whether the general population is exposed or exposure is in an "uncontrolled" situation. In addition to guidelines for evaluating fixed transmitters, the FCC adopted new limits for evaluating exposure from mobile and portable devices, such as cellular telephones and personal communications devices. The FCC also revised its policy with respect to categorically excluding certain transmitters and services from requirements for routine evaluation for compliance with the guidelines.

This bulletin is a revision of the FCC's OST Bulletin 65, originally issued in 1985. Although certain technical information in the original bulletin is still valid, this revised version updates other information and provides additional guidance for evaluating compliance with the the new FCC policies and guidelines. The bulletin is organized into the following sections: Introduction, Definitions and Glossary, Background Information, Prediction Methods, Measuring RF Fields, Controlling Exposure to RF Fields, References and Appendices. Appendix A provides a summary of the new FCC guidelines and the requirements for routine evaluation. Additional information specifically for use in evaluating compliance for radio and television broadcast stations is included in a supplement to this bulletin (Supplement A). A supplement for the Amateur Radio Service will also be issued (Supplement B), and future supplements may be issued to provide additional information for other services. This bulletin and its supplements may be revised, as needed.

In general, the information contained in this bulletin is intended to enable an applicant to make a reasonably quick determination as to whether a proposed or existing facility is in compliance with the limits. In addition to calculations and the use of tables and figures, Section 4, dealing with controlling exposure, should be consulted to ensure compliance, especially with respect to occupational/controlled exposures. In some cases, such as multiple-emitter locations, measurements or a more detailed analysis may be required. In that regard, Section 3 on measuring RF fields provides basic information and references on measurement procedures and instrumentation.

For further information on any of the topics discussed in this bulletin, you may contact the FCC's RF safety group at: +1 202 418-2464. Questions and inquiries can also be e-mailed to: rfsafety@fcc.gov. The FCC's World Wide Web Site provides information on FCC decision documents and bulletins relevant to the RF safety issue. The address is: www.fcc.gov/oet/rfsafety.

DEFINITIONS AND GLOSSARY OF TERMS

The following specific words and terms are used in this bulletin. These definitions are adapted from those included in the American National Standards Institute (ANSI) 1992 RF exposure standard [Reference 1], from NCRP Report No. 67 [Reference 19] and from the FCC's Rules (47 CFR § 2.1 and § 1.1310).

Average (temporal) power. The time-averaged rate of energy transfer.

Averaging time. The appropriate time period over which exposure is averaged for purposes of determining compliance with RF exposure limits (discussed in more detail in Section 1).

Continuous exposure. Exposure for durations exceeding the corresponding averaging time.

Decibel (dB). Ten times the logarithm to the base ten of the ratio of two power levels.

Duty factor. The ratio of pulse duration to the pulse period of a periodic pulse train. Also, may be a measure of the temporal transmission characteristic of an intermittently transmitting RF source such as a paging antenna by dividing average transmission duration by the average period for transmissions. A duty factor of 1.0 corresponds to continuous operation.

Effective radiated power (ERP) (in a given direction). The product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.

Equivalent Isotropically Radiated Power (EIRP). The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

Electric field strength (E). A field vector quantity that represents the force (**F**) on an infinitesimal unit positive test charge (**q**) at a point divided by that charge. Electric field strength is expressed in units of volts per meter (V/m).

Energy density (electromagnetic field). The electromagnetic energy contained in an infinitesimal volume divided by that volume.

Exposure. Exposure occurs whenever and wherever a person is subjected to electric, magnetic or electromagnetic fields other than those originating from physiological processes in the body and other natural phenomena.

Exposure, partial-body. Partial-body exposure results when RF fields are substantially nonuniform over the body. Fields that are nonuniform over volumes comparable to the human body may occur due to highly directional sources, standing-waves, re-radiating sources or in the near field. See **RF "hot spot"**.

Far-field region. That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In this region (also called the free space region), the field has a predominantly plane-wave character, i.e., locally uniform distribution of electric field strength and magnetic field strength in planes transverse to the direction of propagation.

Gain (of an antenna). The ratio, usually expressed in decibels, of the power required at the input of a loss-free reference antenna to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength or the same power density at the same distance. When not specified otherwise, the gain refers to the direction of maximum radiation. Gain may be considered for a specified polarization. Gain may be referenced to an isotropic antenna (dBi) or a half-wave dipole (dBd).

General population/uncontrolled exposure. For FCC purposes, applies to human exposure to RF fields when the general public is exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Therefore, members of the general public always fall under this category when exposure is not employment-related.

Hertz (Hz). The unit for expressing frequency, (f). One hertz equals one cycle per second.

Magnetic field strength (H). A field vector that is equal to the magnetic flux density divided by the permeability of the medium. Magnetic field strength is expressed in units of amperes per meter (A/m).

Maximum permissible exposure (MPE). The rms and peak electric and magnetic field strength, their squares, or the plane-wave equivalent power densities associated with these fields to which a person may be exposed without harmful effect and with an acceptable safety factor.

Near-field region. A region generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point. The near-field region is further subdivided into the reactive near-field region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field, but lacks substantial plane-wave character and is complicated in structure. For most antennas, the outer boundary of the reactive near field region is commonly taken to exist at a distance of one-half wavelength from the antenna surface.

Occupational/controlled exposure. For FCC purposes, applies to human exposure to RF fields when persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure. Occupational/controlled exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits (see definition above), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Peak Envelope Power (PEP). The average power supplied to the antenna transmission line by a radio transmitter during one radiofrequency cycle at the crest of the modulation envelope taken under normal operating conditions.

Power density, average (temporal). The instantaneous power density integrated over a source repetition period.

Power density (S). Power per unit area normal to the direction of propagation, usually expressed in units of watts per square meter (W/m^2) or, for convenience, units such as milliwatts per square centimeter (mW/cm^2) or microwatts per square centimeter ($\mu\text{W/cm}^2$). For plane waves, power density, electric field strength (E) and magnetic field strength (H) are related by the impedance of free space, i.e., 377 ohms, as discussed in Section 1 of this bulletin. Although many survey instruments indicate power density units ("far-field equivalent" power density), the actual quantities measured are E or E^2 or H or H^2 .

Power density, peak. The maximum instantaneous power density occurring when power is transmitted.

Power density, plane-wave equivalent or far-field equivalent. A commonly-used terms associated with any electromagnetic wave, equal in magnitude to the power density of a plane wave having the same electric (E) or magnetic (H) field strength.

Radiofrequency (RF) spectrum. Although the RF spectrum is formally defined in terms of frequency as extending from 0 to 3000 GHz, for purposes of the FCC's exposure guidelines, the frequency range of interest is 300 kHz to 100 GHz.

Re-radiated field. An electromagnetic field resulting from currents induced in a secondary, predominantly conducting, object by electromagnetic waves incident on that object from one or more primary radiating structures or antennas. Re-radiated fields are sometimes called "reflected" or more correctly "scattered fields." The scattering object is sometimes called a "re-radiator" or "secondary radiator".

RF "hot spot." A highly localized area of relatively more intense radio-frequency radiation that manifests itself in two principal ways:

- (1) The presence of intense electric or magnetic fields immediately adjacent to conductive objects that are immersed in lower intensity ambient fields (often referred to as re-radiation), and
- (2) Localized areas, not necessarily immediately close to conductive objects, in which there exists a concentration of RF fields caused by reflections and/or narrow beams produced by high-gain radiating antennas or other highly directional sources. In both cases, the fields are characterized by very rapid changes in field strength with distance. RF hot spots are normally associated with very nonuniform exposure of the body (partial body exposure). This is not to be confused with an actual thermal hot spot within the absorbing body.

Root-mean-square (rms). The effective value, or the value associated with joule heating, of a periodic electromagnetic wave. The rms value is obtained by taking the square root of the mean of the squared value of a function.

Scattered radiation. An electromagnetic field resulting from currents induced in a secondary, conducting or dielectric object by electromagnetic waves incident on that object from one or more primary sources.

Short-term exposure. Exposure for durations less than the corresponding averaging time.

Specific absorption rate (SAR). A measure of the rate of energy absorbed by (dissipated in) an incremental mass contained in a volume element of dielectric materials such as biological tissues. SAR is usually expressed in terms of watts per kilogram (W/kg) or milliwatts per gram (mW/g). Guidelines for human exposure to RF fields are based on SAR thresholds where adverse biological effects may occur. When the human body is exposed to an RF field, the SAR experienced is proportional to the squared value of the electric field strength induced in the body.

Wavelength (λ). The wavelength (λ) of an electromagnetic wave is related to the frequency (f) and velocity (v) by the expression $v = f\lambda$. In free space the velocity of an electromagnetic wave is equal to the speed of light, i.e., approximately 3×10^8 m/s.

Section 1: BACKGROUND INFORMATION

FCC Implementation of NEPA

The National Environmental Policy Act of 1969 (NEPA) requires agencies of the Federal Government to evaluate the effects of their actions on the quality of the human environment.¹ To meet its responsibilities under NEPA, the Commission has adopted requirements for evaluating the environmental impact of its actions.² One of several environmental factors addressed by these requirements is human exposure to RF energy emitted by FCC-regulated transmitters and facilities.

The FCC's Rules provide a list of various Commission actions which may have a significant effect on the environment. If FCC approval to construct or operate a facility would likely result in a significant environmental effect included in this list, the applicant for such a facility must submit an "Environmental Assessment" or "EA" of the environmental effect including information specified in the FCC Rules. It is the responsibility of the applicant to make an initial determination as to whether it is necessary to submit an EA.

If it is necessary for an applicant to submit an EA that document would be reviewed by FCC staff to determine whether the next step in the process, the preparation of an Environmental Impact Statement or "EIS," is necessary. An EIS is only prepared if there is a staff determination that the action in question will have a significant environmental effect. If an EIS is prepared, the ultimate decision as to approval of an application could require a full vote by the Commission, and consideration of the issues involved could be a lengthy process. Over the years since NEPA implementation, there have been relatively few EIS's filed with the Commission. This is because most environmental problems are resolved in the process well prior to EIS preparation, since this is in the best interest of all and avoids processing delays.

Many FCC application forms require that applicants indicate whether their proposed operation would constitute a significant environmental action under our NEPA procedures. When an applicant answers this question on an FCC form, in some cases documentation or an explanation of how an applicant determined that there would **not** be a significant environmental effect may be requested by the FCC operating bureau or office. This documentation may take the form of an environmental statement or engineering statement that accompanies the application. Such a statement is **not** an EA, since an EA is only submitted if there is evidence for a significant environmental effect. In the overwhelming number of cases, applicants attempt to mitigate any potential for a significant environmental effect before submission of either an environmental statement or an EA. This may involve informal

¹ National Environmental Policy Act of 1969, 42 U.S.C. Section 4321, et seq.

² See 47 CFR § 1.1301, et seq.

consultation with FCC staff, either prior to the filing of an application or after an application has been filed, over possible means of avoiding or correcting an environmental problem.

FCC Guidelines for Evaluating Exposure to RF Emissions

In 1985, the FCC first adopted guidelines to be used for evaluating human exposure to RF emissions.³ The FCC revised and updated these guidelines on August 1, 1996, as a result of a rule-making proceeding initiated in 1993.⁴ The new guidelines incorporate limits for Maximum Permissible Exposure (MPE) in terms of electric and magnetic field strength and power density for transmitters operating at frequencies between 300 kHz and 100 GHz. Limits are also specified for localized ("partial body") absorption that are used primarily for evaluating exposure due to transmitting devices such as hand-held portable telephones. Implementation of the new guidelines for mobile and portable devices became effective August 7, 1996. For other applicants and licensees a transition period was established before the new guidelines would apply.⁵

The FCC's MPE limits are based on exposure limits recommended by the National Council on Radiation Protection and Measurements (NCRP)⁶ and, over a wide range of frequencies, the exposure limits developed by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) and adopted by the American National Standards Institute (ANSI) to

³ See *Report and Order*, GEN Docket No. 79-144, 100 FCC 2d 543 (1985); and *Memorandum Opinion and Order*, 58 RR 2d 1128 (1985). The guidelines originally adopted by the FCC were the 1982 RF protection guides issued by the American National Standards Institute (ANSI).

⁴ See *Report and Order*, ET Docket 93-62, FCC 96-326, adopted August 1, 1996, 61 Federal Register 41,006 (1996), 11 FCC Record 15,123 (1997). The FCC initiated this rule-making proceeding in 1993 in response to the 1992 revision by ANSI of its earlier guidelines for human exposure. The Commission responded to seventeen petitions for reconsideration filed in this docket in two separate Orders: *First Memorandum Opinion and Order*, FCC 96-487, adopted December 23, 1996, 62 Federal Register 3232 (1997), 11 FCC Record 17,512 (1997); and *Second Memorandum Opinion and Order and Notice of Proposed Rulemaking*, adopted August 25, 1997.

⁵ This transition period was recently extended. With the exception of the Amateur Radio Service, the date now established for the end of the transition period is October 15, 1997. See *Second Memorandum Opinion and Order and Notice of Proposed Rule Making*, ET Docket 93-62, adopted August 25, 1997. Therefore, the new guidelines will apply to applications filed on or after this date. For the Amateur Service only, the new guidelines will apply to applications filed on or after January 1, 1998. In addition, the Commission has adopted a date certain of September 1, 2000, by which time all existing facilities and devices must be in compliance with the new guidelines (see *Second Memorandum Opinion and Order*).

⁶ See *Reference 20*, "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86 (1986), National Council on Radiation Protection and Measurements (NCRP), Bethesda, MD. The NCRP is a non-profit corporation chartered by the U.S. Congress to develop information and recommendations concerning radiation protection.

replace the 1982 ANSI guidelines.⁷ Limits for localized absorption are based on recommendations of both ANSI/IEEE and NCRP. The FCC's new guidelines are summarized in Appendix A.

In reaching its decision on adopting new guidelines the Commission carefully considered the large number of comments submitted in its rule-making proceeding, and particularly those submitted by the U.S. Environmental Protection Agency (EPA), the Food and Drug Administration (FDA) and other federal health and safety agencies. The new guidelines are based substantially on the recommendations of those agencies, and it is the Commission's belief that they represent a consensus view of the federal agencies responsible for matters relating to public safety and health.

The FCC's limits, and the NCRP and ANSI/IEEE limits on which they are based, are derived from exposure criteria quantified in terms of specific absorption rate (SAR).⁸ The basis for these limits is a whole-body averaged SAR threshold level of 4 watts per kilogram (4 W/kg), as averaged over the entire mass of the body, above which expert organizations have determined that potentially hazardous exposures may occur. The new MPE limits are derived by incorporating safety factors that lead, in some cases, to limits that are more conservative than the limits originally adopted by the FCC in 1985. Where more conservative limits exist they do not arise from a fundamental change in the RF safety criteria for whole-body averaged SAR, but from a precautionary desire to protect subgroups of the general population who, potentially, may be more at risk.

The new FCC exposure limits are also based on data showing that the human body absorbs RF energy at some frequencies more efficiently than at others. As indicated by Table 1 in Appendix A, the most restrictive limits occur in the frequency range of 30-300 MHz where whole-body absorption of RF energy by human beings is most efficient. At other frequencies whole-body absorption is less efficient, and, consequently, the MPE limits are less restrictive.

MPE limits are defined in terms of power density (units of milliwatts per centimeter squared: mW/cm^2), electric field strength (units of volts per meter: V/m) and magnetic field strength (units of amperes per meter: A/m). In the far-field of a transmitting antenna, where the electric field vector (E), the magnetic field vector (H), and the direction of propagation

⁷ See *Reference 1*, ANSI/IEEE C95.1-1992, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz." Copyright 1992, The Institute of Electrical and Electronics Engineers, Inc., New York, NY. The 1992 ANSI/IEEE exposure guidelines for field strength and power density are similar to those of NCRP Report No. 86 for most frequencies except those above 1.5 GHz.

⁸ Specific absorption rate is a measure of the rate of energy absorption by the body. SAR limits are specified for both whole-body exposure and for partial-body or localized exposure (generally specified in terms of spatial peak values).

can be considered to be all mutually orthogonal ("plane-wave" conditions), these quantities are related by the following equation.⁹

$$S = \frac{E^2}{3770} = 37.7H^2 \quad (1)$$

where: S = power density (mW/cm²)
E = electric field strength (V/m)
H = magnetic field strength (A/m)

In the near-field of a transmitting antenna the term "far-field equivalent" or "plane-wave equivalent" power density is often used to indicate a quantity calculated by using the near-field values of E² or H² as if they were obtained in the far-field. As indicated in Table 1 of Appendix A, for near-field exposures the values of plane-wave equivalent power density are given in some cases for reference purposes only. These values are sometimes used as a convenient comparison with MPEs for higher frequencies and are displayed on some measuring instruments.

The FCC guidelines incorporate two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to exposure. The decision as to which tier applies in a given situation should be based on the application of the following definitions.

Occupational/controlled exposure limits apply to situations in which persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure. Occupational/controlled exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits (see below), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means. As discussed later, the occupational/controlled exposure limits also apply to amateur radio operators and members of their immediate household.

General population/uncontrolled exposure limits apply to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Therefore, members of the general public would always be considered under this category when exposure is not employment-related, for example, in the case of a telecommunications tower that exposes persons in a nearby residential area.

⁹ Note that this equation is written so that power density is expressed in units of mW/cm². The impedance of free space, 377 ohms, is used in deriving the equation.

For purposes of applying these definitions, awareness of the potential for RF exposure in a workplace or similar environment can be provided through specific training as part of an RF safety program. Warning signs and labels can also be used to establish such awareness as long as they provide information, in a prominent manner, on risk of potential exposure and instructions on methods to minimize such exposure risk.¹⁰ However, warning labels placed on low-power consumer devices such as cellular telephones are not considered sufficient to achieve the awareness necessary to qualify these devices as operating under the occupational/controlled category. In those situations the general population/uncontrolled exposure limits will apply.

A fundamental aspect of the exposure guidelines is that they apply to power densities or the squares of the electric and magnetic field strengths that are spatially averaged over the body dimensions. Spatially averaged RF field levels most accurately relate to estimating the whole-body averaged SAR that will result from the exposure and the MPEs specified in Table 1 of Appendix A are based on this concept. This means that local values of exposures that exceed the stated MPEs may not be related to non-compliance if the spatial average of RF fields over the body does not exceed the MPEs. Further discussion of spatial averaging as it relates to field measurements can be found in Section 3 of this bulletin and in the ANSI/IEEE and NCRP reference documents noted there.

Another feature of the exposure guidelines is that exposures, in terms of power density, E^2 or H^2 , may be averaged over certain periods of time with the average not to exceed the limit for continuous exposure.¹¹ As shown in Table 1 of Appendix A, the averaging time for occupational/controlled exposures is 6 minutes, while the averaging time for general population/uncontrolled exposures is 30 minutes. It is important to note that for general population/uncontrolled exposures it is often not possible to control exposures to the extent that averaging times can be applied. In those situations, it is often necessary to assume continuous exposure.

As an illustration of the application of time-averaging to occupational/controlled exposure consider the following. The relevant interval for time-averaging for occupational/controlled exposures is six minutes. This means, for example, that during any given six-minute period a worker could be exposed to two times the applicable power density limit for three minutes as long as he or she were not exposed at all for the preceding or following three minutes. Similarly, a worker could be exposed at three times the limit for two minutes as long as no exposure occurs during the preceding or subsequent four minutes, and so forth.

¹⁰ For example, a sign warning of RF exposure risk and indicating that individuals should not remain in the area for more than a certain period of time could be acceptable. Reference [3] provides information on acceptable warning signs.

¹¹ Note that although the FCC did not explicitly adopt limits for *peak* power density, guidance on these types of exposures can be found in Section 4.4 of the ANSI/IEEE C95.1-1992 standard.

This concept can be generalized by considering Equation (2) that allows calculation of the allowable time(s) for exposure at [a] given power density level(s) during the appropriate time-averaging interval to meet the exposure criteria of Table 1 of Appendix A. The sum of the products of the exposure levels and the allowed times for exposure must equal the product of the appropriate MPE limit and the appropriate time-averaging interval.

$$\sum S_{exp} t_{exp} = S_{limit} t_{avg} \quad (2)$$

where:

S_{exp}	= power density level of exposure (mW/cm ²)
S_{limit}	= appropriate power density MPE limit (mW/cm ²)
t_{exp}	= allowable time of exposure for S_{exp}
t_{avg}	= appropriate MPE averaging time

For the example given above, if the MPE limit is 1 mW/cm², then the right-hand side of the equation becomes 6 mW-min/cm² (1 mW/cm² X 6 min). Therefore, if an exposure level is determined to be 2 mW/cm², the allowed time for exposure at this level during any six-minute interval would be a total of 3 minutes, since the left side of the equation must equal 6 (2 mW/cm² X 3 min). Of course, many other combinations of exposure levels and times may be involved during a given time-averaging interval. However, as long as the sum of the products on the left side of the equation equals the right side, the *average* exposure will comply with the MPE limit. It is very important to remember that time-averaging applies to *any* interval of t_{avg} . Therefore, in the above example, consideration would have to be given to the exposure situation both before and after the allowed three-minute exposure. The time-averaging interval can be viewed as a "sliding" period of time, six minutes in this case.

Another important point to remember concerning the FCC's exposure guidelines is that they constitute *exposure* limits (not *emission* limits), and they are relevant only to locations that are *accessible* to workers or members of the public. Such access can be restricted or controlled by appropriate means such as the use of fences, warning signs, etc., as noted above. For the case of occupational/controlled exposure, procedures can be instituted for working in the vicinity of RF sources that will prevent exposures in excess of the guidelines. An example of such procedures would be restricting the time an individual could be near an RF source or requiring that work on or near such sources be performed while the transmitter is turned off or while power is appropriately reduced. In the case of broadcast antennas, the use of auxiliary antennas could prevent excessive exposures to personnel working on or near the main antenna site, depending on the separation between the main and auxiliary antennas. Section 4 of this bulletin should be consulted for further information on controlling exposure to comply with the FCC guidelines.

Applicability of New Guidelines

The FCC's environmental rules regarding RF exposure identify particular categories of existing and proposed transmitting facilities, operations and devices for which licensees and applicants are required to conduct an initial environmental evaluation, and prepare an Environmental Assessment if the evaluation indicates that the transmitting facility, operation or device exceeds or will exceed the FCC's RF exposure guidelines. For transmitting facilities, operations and devices not specifically identified, the Commission has determined, based on calculations, measurement data and other information, that such RF sources offer little potential for causing exposures in excess of the guidelines. Therefore, the Commission "categorically excluded" applicants and licensees from the requirement to perform routine, initial environmental evaluations of such sources to demonstrate compliance with our guidelines. However, the Commission still retains the authority to request that a licensee or an applicant conduct an environmental evaluation and, if appropriate, file environmental information pertaining to an otherwise categorically excluded RF source if it is determined that there is a possibility for significant environmental impact due to RF exposure.¹²

In that regard, all transmitting facilities and devices regulated by this Commission that are the subject of an FCC decision or action (e.g., grant of an application or response to a petition or inquiry) are expected to comply with the appropriate RF radiation exposure guidelines, or, if not, to file an Environmental Assessment (EA) for review under our NEPA procedures, if such is required. It is important to emphasize that the categorical exclusions are *not* exclusions from *compliance* but, rather, exclusions from performing routine evaluations to demonstrate compliance. Normally, the exclusion from performing a routine evaluation will be a sufficient basis for assuming compliance, unless an applicant or licensee is otherwise notified by the Commission or has reason to believe that the excluded transmitter or facility encompasses exceptional characteristics that could cause non-compliance.

It should also be stressed that even though a transmitting source or facility may not be categorically excluded from routine evaluation, no further environmental processing is required once it has been demonstrated that exposures are within the guidelines, as specified in Part 1 of our rules. These points have been the source of some confusion in the past among FCC licensees and applicants, some of whom have been under the impression that filing an EA is always required.

In adopting its new exposure guidelines, the Commission also adopted new rules indicating which transmitting facilities, operations and devices will be categorically excluded from performing routine, initial evaluations. The new exclusion criteria are based on such factors as type of service, antenna height, and operating power. The new criteria were adopted in an attempt to obtain greater consistency and scientific rigor in determining requirements for RF evaluation across the various FCC-regulated services.

¹² See 47 CFR §§ 1.1307(c) and (d).

Routine environmental evaluation for RF exposure is required for transmitters, facilities or operations that are included in the categories listed in Table 2 of Appendix A or in FCC rule parts 2.1091 and 2.1093 (for portable and mobile devices). This requirement applies to some, but not necessarily all, transmitters, facilities or operations that are authorized under the following parts of our rules: 5, 15, 21 (Subpart K), 22 (Subpart E), 22 (Subpart H), 24, 25, 26, 27, 73, 74 (Subparts A, G, I, and L), 80 (ship earth stations), 90 (paging operations and Specialized Mobile Radio), 97 and 101 (Subpart L). Within a specific service category, conditions are listed in Table 2 of Appendix A to determine which transmitters will be subject to routine evaluation. These conditions are generally based on one or more of the following variables: (1) operating power, (2) location, (3) height above ground of the antenna and characteristics of the antenna or mode of transmission. In the case of Part 15 devices, only devices that transmit on millimeter wave frequencies and unlicensed Personal Communications Service (PCS) devices are covered, as noted in rule parts 2.1091 and 2.1093 (see section on mobile and portable devices of Appendix A).

Transmitters and facilities not included in the specified categories are excluded from routine evaluation for RF exposure. We believe that such transmitting facilities generally pose little or no risk for causing exposures in excess of the guidelines. However, as noted above, in exceptional cases the Commission may, on its own merit or as the result of a petition, require environmental evaluation of transmitters or facilities even though they are otherwise excluded from routine evaluation. Also, at multiple-transmitter sites applications for non-excluded transmitters should consider significant contributions of other co-located transmitters (see discussion of multiple-transmitter evaluation in Section 2).

If a transmitter operates using relatively high power, and there is a possibility that workers or the public could have access to the transmitter site, such as at a rooftop site, then routine evaluation is justified. In Table 2 of Appendix A, an attempt was made to identify situations in the various services where such conditions could prevail. In general, at rooftop transmitting sites evaluation will be required if power levels are above the values indicated in Table 2 of Appendix A. These power levels were chosen based on generally "worst-case" assumptions where the most stringent uncontrolled/general population MPE limit might be exceeded within several meters of transmitting antennas at these power levels. In the case of paging antennas, the likelihood that duty factors, although high, would not normally be expected to be 100% was also considered. Of course, if procedures are in place at a site to limit accessibility or otherwise control exposure so that the safety guidelines are met, then the site is in compliance and no further environmental processing is necessary under our rules.

Tower-mounted ("non-rooftop") antennas that are used for cellular telephone, PCS, and Specialized Mobile Radio (SMR) operations warrant a somewhat different approach for evaluation. While there is no evidence that typical installations in these services cause ground-level exposures in excess of the MPE limits, construction of these towers has been a topic of ongoing public controversy on environmental grounds, and we believe it necessary to ensure that there is no likelihood of excessive exposures from these antennas. Although we believe there is no need to require routine evaluation of towers where antennas are mounted high above the ground, out of an abundance of caution the FCC requires that tower-mounted

installations be evaluated if antennas are mounted lower than 10 meters above ground and the total power of all channels being used is over 1000 watts effective radiated power (ERP), or 2000 W ERP for broadband PCS.¹³ These height and power combinations were chosen as thresholds recognizing that a theoretically "worst case" site could use many channels and several thousand watts of power. At such power levels a height of 10 meters above ground is not an unreasonable distance for which an evaluation generally would be advisable. For antennas mounted higher than 10 meters, measurement data for cellular facilities have indicated that ground-level power densities are typically hundreds to thousands of times below the new MPE limits.

In view of the expected proliferation of these towers in the future and possible use of multiple channels and power levels at these installations, and to ensure that tower installations are properly evaluated when appropriate, we have instituted these new requirements for this limited category of tower-mounted antennas in these services. For consistency we have instituted similar requirements for several other services that could use relatively high power levels with antennas mounted on towers lower than 10 meters above ground.

Paging systems operated under Part 22 (Subpart E) and Part 90 of our rules previously have been categorically exempted from routine RF evaluation requirements. However, the potential exists that the new, more restrictive limits may be exceeded in accessible areas by relatively high-powered paging transmitters with rooftop antennas.¹⁴ These transmitters may operate with high duty factors in densely populated urban environments. The record and our own data indicate the need for ensuring appropriate evaluation of such facilities, especially at multiple transmitter sites. Accordingly, paging stations authorized under Part 22 (Subpart E) and Part 90 are also subject to routine environmental evaluation for RF exposure if an antenna is located on a rooftop and if its ERP exceeds 1000 watts.

Mobile and Portable Devices

As noted in Appendix A, mobile and portable transmitting devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services (PCS), the General Wireless Communications Service, the Wireless Communication Service, the Satellite Communications services, the Maritime Services (ship earth stations only) and Specialized Mobile Radio Service authorized, respectively, under Part 22 (Subpart H), Part 24, Part 25, Part 26, Part 27, Part 80, and Part 90 of the FCC's Rules are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use. Unlicensed PCS, NII and millimeter wave devices are also subject to routine environmental evaluation for RF exposure

¹³ For broadband PCS, 2000 W is used as a threshold, instead of 1000 W, since at these operating frequencies the exposure criteria are less restrictive by about a factor of two.

¹⁴ For example, under Part 90, paging operations in the 929-930 MHz band may operate with power levels as high as 3500 W ERP.

prior to equipment authorization or use. All other mobile, portable, and unlicensed transmitting devices are normally categorically excluded from routine environmental evaluation for RF exposure (see Section 2 and Appendix A for further details).

For purposes of these requirements mobile devices are defined by the FCC as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between radiating structures and the body of the user or nearby persons. These devices are normally evaluated for exposure potential with relation to the MPE limits given in Table 1 of Appendix A.

The FCC defines portable devices, for purposes of these requirements, as transmitters whose radiating structures are designed to be used within 20 centimeters of the body of the user. As explained later, in Section 2 and in Appendix A, portable devices are to be evaluated with respect to limits for specific absorption rate (SAR).

Operations in the Amateur Radio Service

In the FCC's recent *Report and Order*, certain amateur radio installations were made subject to routine evaluation for compliance with the FCC's RF exposure guidelines.¹⁵ Also, amateur licensees will be expected to demonstrate their knowledge of the FCC guidelines through examinations. Applicants for new licenses and renewals also will be required to demonstrate that they have read and that they understand the applicable rules regarding RF exposure. Before causing or allowing an amateur station to transmit from any place where the operation of the station could cause human exposure to RF radiation levels in excess of the FCC guidelines amateur licensees are now required to take certain actions. A routine RF radiation evaluation is required if the transmitter power of the station exceeds the levels shown in Table 1 and specified in 47 CFR § 97.13(c)(1).¹⁶ Otherwise the operation is categorically excluded from routine RF radiation evaluation, except as a result of a specific motion or petition as specified in Sections 1.1307(c) and (d) of the FCC's Rules, (see earlier discussion in Section 1 of this bulletin).

The Commission's *Report and Order* instituted a requirement that operator license examination question pools will include questions concerning RF safety at amateur stations. An additional five questions on RF safety will be required within each of three written examination elements. The Commission also adopted the proposal of the American Radio

¹⁵ See para. 160 of *Report and Order*, ET Dkt 93-62. See also, 47 CFR § 97.13, as amended.

¹⁶ These levels were chosen to roughly parallel the frequency of the MPE limits of Table 1 in Appendix A. These levels were modified from the Commission's original decision establishing a flat 50 W power threshold for routine evaluation of amateur stations (see *Second Memorandum Opinion and Order*, ET Docket 93-62, FCC 97-303, adopted August 25, 1997).

TABLE 1. Power thresholds for routine evaluation of amateur radio stations.

Wavelength Band	Transmitter Power (watts)
MF	
160 m	500
HF	
80 m	500
75 m	500
40 m	500
30 m	425
20 m	225
17 m	125
15 m	100
12 m	75
10 m	50
VHF (all bands)	50
UHF	
70 cm	70
33 cm	150
23 cm	200
13 cm	250
SHF (all bands)	250
EHF (all bands)	250

Relay League (ARRL) that amateur operators should be required to certify, as part of their license application process, that they have read and understand our bulletins and the relevant FCC rules.

When routine evaluation of an amateur station indicates that exposure to RF fields could be in excess of the exposure limits specified by the FCC (see Appendix A), the licensee must take action to correct the problem and ensure compliance (see Section 4 of this bulletin on controlling exposure). Such actions could be in the form of modifying patterns of operation, relocating antennas, revising a station's technical parameters such as frequency, power or emission type or combinations of these and other remedies.

In complying with the Commission's *Report and Order*, amateur operators should follow a policy of systematic avoidance of excessive RF exposure. The Commission has said that it will continue to rely upon amateur operators, in constructing and operating their stations, to take steps to ensure that their stations comply with the MPE limits for both occupational/controlled and general public/uncontrolled situations, as appropriate. In that regard, amateur radio operators and members of their immediate household are considered to be in a "controlled environment" and are subject to the occupational/controlled MPE limits. Neighbors who are not members of an amateur operator's household are considered to be members of the general public, since they cannot reasonably be expected to exercise control over their exposure. In those cases general population/uncontrolled exposure MPE limits will apply.

In order to qualify for use of the occupational/controlled exposure criteria, appropriate restrictions on access to high RF field areas must be maintained and educational instruction in RF safety must be provided to individuals who are members of the amateur operator's household. Persons who are not members of the amateur operator's household but who are present temporarily on an amateur operator's property may also be considered to fall under the occupational/controlled designation provided that appropriate information is provided them about RF exposure potential if transmitters are in operation and such persons are exposed in excess of the general population/uncontrolled limits.

Amateur radio facilities represent a special case for determining exposure, since there are many possible antenna types that could be designed and used for amateur stations. However, several relevant points can be made with respect to analyzing amateur radio antennas for potential exposure that should be helpful to amateur operators in performing evaluations.

First of all, the generic equations described in this bulletin can be used for analyzing fields due to almost all antennas, although the resulting estimates for power density may be overly-conservative in some cases. Nonetheless, for general radiators and for aperture antennas, if the user is knowledgeable about antenna gain, frequency, power and other relevant factors, the equations in this section can be used to estimate field strength and power density as described earlier. In addition, other resources are available to amateur radio operators for analyzing fields near their antennas. The ARRL Radio Amateur Handbook

contains an excellent section on analyzing amateur radio facilities for compliance with RF guidelines (Reference [4]). Also, the FCC and the EPA conducted a study of several amateur radio stations in 1990 that provides a great deal of measurement data for many types of antennas commonly used by amateur operators (Reference [10]).

Amateur radio organizations and licensees are encouraged to develop their own more detailed evaluation models and methods for typical antenna configurations and power/frequency combinations. The FCC is working with the amateur radio community to develop a supplement to this bulletin that will be designed specifically for evaluating amateur radio installations. For example, the supplement will contain information on projected minimum exclusion distances from typical amateur antenna installations. The supplement should be completed soon after release of this bulletin. Once the amateur radio supplement is released by the FCC it will be made available for downloading at the FCC's World Wide Web Site for "RF safety." Amateur radio applicants and licensees are encouraged to monitor the Web Site for release of the supplement. The address is: www.fcc.gov/oet/rfsafety. Information on availability of the supplement, as well as other RF-related questions, can be directed to the FCC's "RF Safety Program" at: (202) 418-2464 or to: rfsafety@fcc.gov.

Section 2: PREDICTION METHODS

The material in this section is designed to provide assistance in determining whether a given facility would be in compliance with guidelines for human exposure to RF radiation. The calculational methods discussed below should be helpful in evaluating a particular exposure situation. However, for certain transmitting facilities, such as radio and television broadcast stations, a specific supplement to this bulletin has been developed containing information and compliance guidelines specific to those stations.¹⁷ Therefore, applicants for radio and television broadcast facilities may wish to first consult this supplement that concentrates on AM radio, FM radio and television broadcast antennas. Applicants for many broadcast facilities should be able to determine whether a given facility would be in compliance with FCC guidelines by simply consulting the tables and figures in this supplement. However, in addition, with respect to occupational/controlled exposure, all applicants should consult Section 4 of this bulletin concerning controlling exposures that may occur during maintenance or other procedures carried out at broadcast and other telecommunications sites.

Applicants may consult the relevant sections below, which describe how to estimate field strength and power density levels from typical, general radiators as well as from aperture

¹⁷ *Supplement A to OET Bulletin 65, Version 97-01, Additional Information for Radio and Television Broadcast Stations.* This supplement can be downloaded from the FCC's RF Safety World Wide Web Site: www.fcc.gov/oet/rfsafety. For further information contact the RF safety program at: +1 (202) 418-2464.

antennas such as microwave and satellite dish antennas. The general equations given below can be used for predicting field strength and power density in the vicinity of most antennas, including those used for paging and in the commercial mobile radio service (CMRS). They can also be used for making conservative predictions of RF fields in the vicinity of antennas used for amateur radio transmissions, as discussed earlier.

Equations for Predicting RF Fields

Calculations can be made to predict RF field strength and power density levels around typical RF sources. For example, in the case of a single radiating antenna, a prediction for power density in the far-field of the antenna can be made by use of the general Equations (3) or (4) below [for conversion to electric or magnetic field strength see Equation (1) in Section 1]. These equations are generally accurate in the far-field of an antenna but will over-predict power density in the near field, where they could be used for making a "worst case" or conservative prediction.

$$S = \frac{PG}{4\pi R^2} \quad (3)$$

where: S = power density (in appropriate units, e.g. mW/cm²)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

or:

$$S = \frac{EIRP}{4\pi R^2} \quad (4)$$

where: EIRP = equivalent (or effective) isotropically radiated power

When using these and other equations care must be taken to use the **correct units** for all variables. For example, in Equation (3), if power density in units of mW/cm² is desired then power should be expressed in milliwatts and distance in cm. Other units may be used, but care must be taken to use correct conversion factors when necessary. Also, it is important to note that the power gain factor, **G**, in Equation (3) is normally **numeric** gain. Therefore,

when power gain is expressed in logarithmic terms, i.e., dB, a conversion is required using the relation:

$$G = 10^{\frac{dB}{10}}$$

For example, a logarithmic power gain of 14 dB is equal to a numeric gain of 25.12.

In some cases operating power may be expressed in terms of "effective radiated power" or "ERP" instead of EIRP. ERP is power referenced to a half-wave dipole radiator instead of to an isotropic radiator. Therefore, if ERP is given it is necessary to convert ERP into EIRP in order to use the above equations. This is easily done by multiplying the ERP by the factor of 1.64, which is the gain of a half-wave dipole relative to an isotropic radiator. For example, if ERP is used in Equation (4) the relation becomes:

$$S = \frac{EIRP}{4\pi R^2} = \frac{1.64 ERP}{4\pi R^2} = \frac{0.41 ERP}{\pi R^2} \quad (5)$$

For a truly worst-case prediction of power density at or near a surface, such as at ground-level or on a rooftop, 100% reflection of incoming radiation can be assumed, resulting in a potential doubling of predicted field strength and a four-fold increase in (far-field equivalent) power density. In that case Equations (3) and (4) can be modified to:

$$S = \frac{(2)^2 PG}{4\pi R^2} = \frac{PG}{\pi R^2} = \frac{EIRP}{\pi R^2} \quad (6)$$

In the case of FM radio and television broadcast antennas, the U.S. Environmental Protection Agency (EPA) has developed models for predicting ground-level field strength and power density [Reference 11]. The EPA model recommends a more realistic approximation for ground reflection by assuming a maximum 1.6-fold increase in field strength leading to an

increase in power density of 2.56 (1.6 X 1.6). Equation (4) can then be modified to:

$$S = \frac{2.56 \text{ EIRP}}{4\pi R^2} = \frac{0.64 \text{ EIRP}}{\pi R^2} \quad (7)$$

If ERP is used in Equation (7), the relation becomes:

$$S = \frac{0.64 \text{ EIRP}}{\pi R^2} = \frac{(0.64)(1.64) \text{ ERP}}{\pi R^2} = \frac{1.05 \text{ ERP}}{\pi R^2} \quad (8)$$

It is sometimes convenient to use units of microwatts per centimeter squared ($\mu\text{W}/\text{cm}^2$) instead of mW/cm^2 in describing power density. The following simpler form of Equation (8) can be derived if power density, **S**, is to be expressed in units of $\mu\text{W}/\text{cm}^2$:

$$S = \frac{33.4 \text{ ERP}}{R^2} \quad (9)$$

where: S = power density in $\mu\text{W}/\text{cm}^2$
ERP = power in watts
R = distance in meters

An example of the use of the above equations follows. A station is transmitting at a frequency of 100 MHz with a total nominal ERP (including all polarizations) of 10 kilowatts (10,000 watts) from a tower-mounted antenna. The height to the center of radiation is 50 meters above ground-level. Using the formulas above, what would be the calculated "worst-case" power density that could be expected at a point 2 meters above ground (approximate head level) and at a distance of 20 meters from the base of the tower? Note that this type of analysis **does not** take into account the vertical radiation pattern of the antenna, i.e., no information on directional characteristics of signal propagation is considered. Use of actual vertical radiation pattern data for the antenna would most likely significantly reduce ground-level exposure predictions from those calculated below (see later discussion), resulting in a more realistic estimate of the actual exposure levels.

From simple trigonometry the distance **R** can be calculated to be 52 meters [square root of: $(48)^2 + (20)^2$], assuming essentially flat terrain. Therefore, using Equation (9), the

calculated conservative "worst case" power density is:

$$S = \frac{33.4 (10,000 \text{ watts})}{(52 \text{ m})^2} = \text{about } 124 \text{ } \mu\text{W}/\text{cm}^2$$

By consulting Table 1 of Appendix A it can be determined that the limit for general population/uncontrolled exposure at 100 MHz is 0.2 mW/cm² or 200 μW/cm². Therefore, this calculation shows that even under worst-case conditions this station would comply with the general population/uncontrolled limits, at least at a distance of 20 meters from the tower. Similar calculations could be made to ensure compliance at other locations, such as at the base of the tower where the shortest direct line distance, R, to the ground would occur.

Relative Gain and Main-Beam Calculations

The above-described equations can be used to calculate fields from a variety of radiating antennas, such as omni-directional radiators, dipole antennas and antennas incorporating directional arrays. However, in many cases the use of equations such as Equations (3) and (4) will result in an overly conservative "worst case" prediction of the field at a given point. Alternatively, if information concerning an antenna's vertical radiation pattern is known, a relative field factor (relative gain) derived from such a pattern can be incorporated into the calculations to arrive at a more accurate representation of the field at a given point of interest. For example, in the case of an antenna pointing toward the horizon, if the relative gain in the main beam is 1.0, then in other directions downward from horizontal the field may be significantly less than 1.0. Therefore, radiation from the antenna directly toward the ground may be significantly reduced from the omni-directional case and a more realistic prediction of the field can be obtained for the point of interest.

For example, in the calculation above, it can be shown from trigonometry that the depression angle below horizontal of the vector corresponding to the distance, R, is about 68°. For purposes of illustration, assume that the antenna in this example has its main beam pointed approximately toward the horizon and, at a depression angle of 68°, the field relative to the main beam (relative gain) is -6 dB (a factor of 0.5 in terms of field strength and 0.25 in terms of power density). In that case the calculation above can be modified giving a more

accurate representation of the power density at the ground-level point of interest, as follows.

$$S = \frac{33.4 F^2 ERP}{R^2} = \frac{33.4 (0.5)^2 (10,000 \text{ watts})}{(52 \text{ m})^2} = \text{about } 31 \text{ } \mu\text{W}/\text{cm}^2$$

where: F = the relative field factor (relative numeric gain)

In general, Equation (9) can be modified to:

$$S = \frac{33.4 (F^2) ERP}{R^2} \quad (10)$$

where: S = power density in $\mu\text{W}/\text{cm}^2$
F = relative field factor (relative numeric gain)
ERP = power in watts
R = distance in meters

When the point of interest where exposure may occur is in or near the main radiated beam of an antenna, Equation (3) or its derivatives can be used. In other words, the factor, F, in such cases would be assumed to be 1.0. Such cases occur when, for example, a nearby building or rooftop may be in the main beam of a radiator. For convenience in determining exposures in such situations, Equation (3) has been used to derive Figures 1 and 2. These figures allow a quick determination of the power density at a given distance from an antenna in its main beam for various levels of ERP.¹⁸ Intermediate ERPs can be estimated by interpolation, or the next highest ERP level can be used as a worst case approximation.

Figure 1 assumes no reflection off of a surface. However, at a rooftop location where the main-beam may be directed parallel and essentially along or only slightly above the surface of the roof, there may be reflected waves that would contribute to exposure. Therefore, Figure 2 was derived for the latter case using the EPA-recommended reflection factor of $(1.6)^2 = 2.56$ (see earlier discussion), and the values shown are more conservative. When using Figures 1 or 2 a given situation should be considered on its own merits to determine which figure is more appropriate. For rooftop locations it is also important to note that exposures *inside* a building can be expected to be reduced by at least 10-20 dB due to attenuation caused by building materials in the walls and roof.

¹⁸ To convert to EIRP use the relation: EIRP = ERP X 1.64.

Main-Beam Exposure (No Reflection)

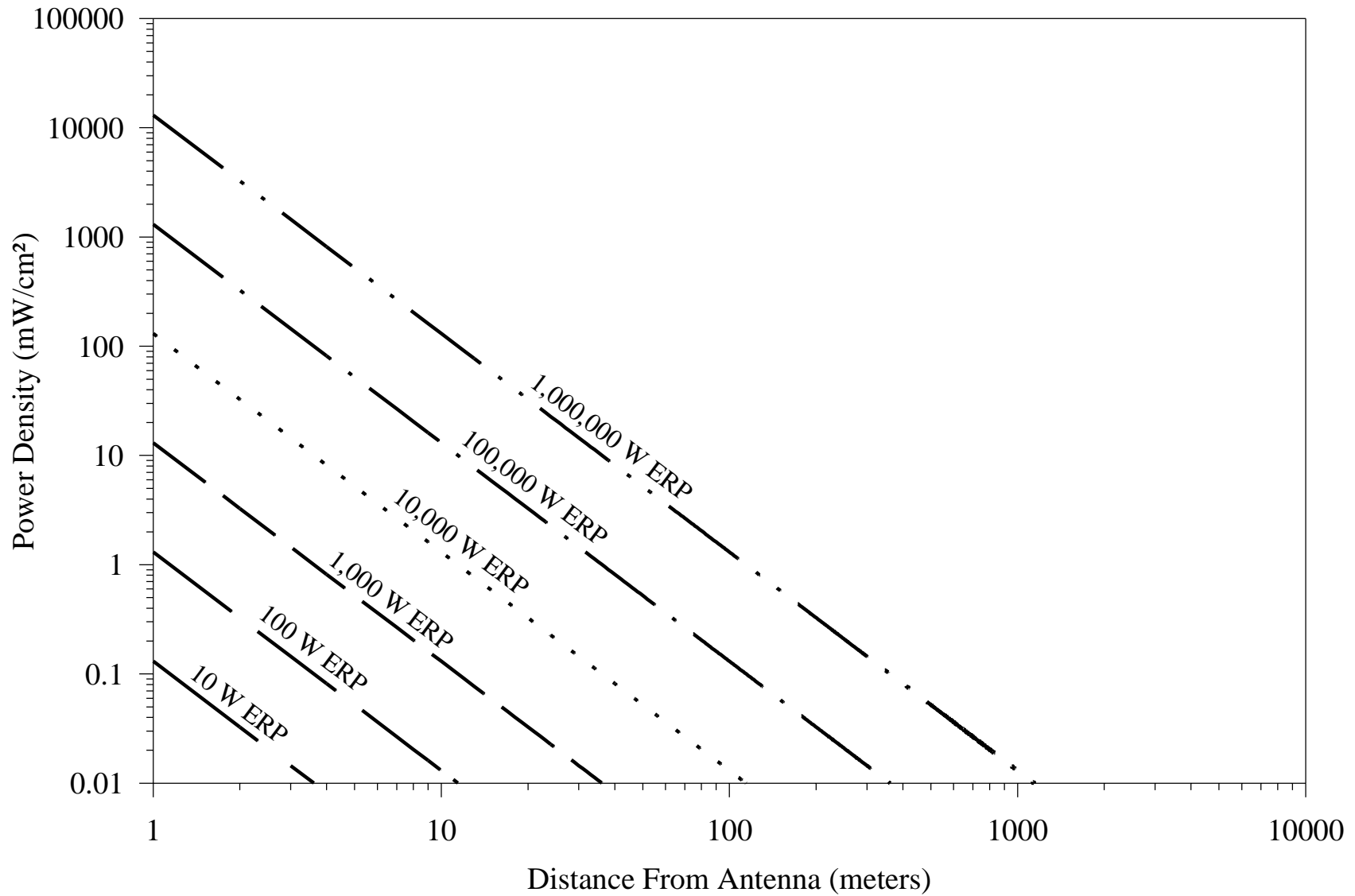


FIGURE 1. Power Density vs. Distance (assumes no surface reflection).

Main-Beam Exposure (With Reflection)

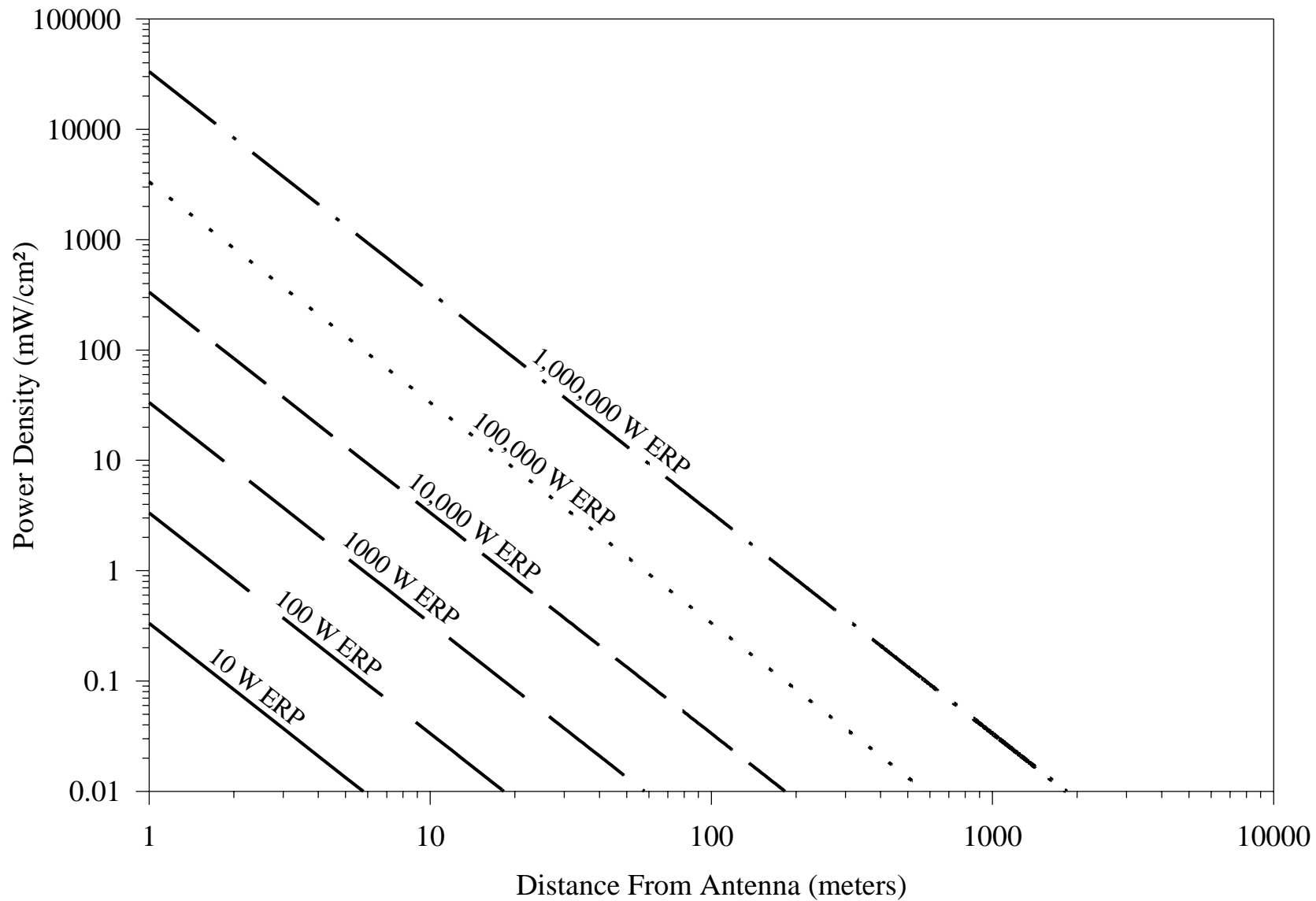


FIGURE 2. Power Density vs. Distance (assumes surface reflection).

Aperture Antennas

Aperture antennas include those used for such applications as satellite-earth stations, point-to-point microwave radio and various types of radar applications. Generally, these types of antennas have parabolic surfaces and many have circular cross sections. They are characterized by their high gain which results in the transmission of power in a well-defined collimated beam with little angular divergence. Systems using aperture antennas operate at microwave frequencies, i.e., generally above 900 MHz.

Those systems involved in telecommunications applications operate with power levels that depend on the distance between transmit and receive antennas, the number of channels required (bandwidth) and antenna gains of transmit and receive antennas. The antennas used typically have circular cross sections, where antenna diameter is an important characteristic that determines the antenna gain. With regard to some operations, such as satellite-earth station transmitting antennas, the combination of high transmitter power and large antenna diameter (high gain) produces regions of significant power density that may extend over relatively large distances in the main beam. Many "dish" type antennas used for satellite-earth station transmissions utilize the Cassegrain design in which power is fed to the antenna from a waveguide located at the center of the parabolic reflector. Radiation from this source is then incident on a small hyperbolic sub-reflector located between the power feed and the focal point of the antenna and is then reflected back to the main reflector resulting in the transmission of a collimated beam. An example of this is illustrated in Figure 3.

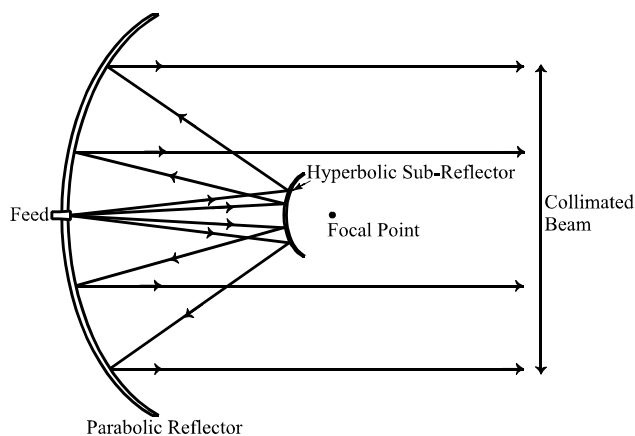


FIGURE 3. Cassegrain Antenna

Because of the highly directional nature of these and other aperture antennas, the likelihood of significant human exposure to RF radiation is considerably reduced. The power densities existing at locations where people may be typically exposed are substantially less

than on-axis power densities. Factors that must be taken into account in assessing the potential for exposure are main-beam orientation, antenna height above ground, location relative to where people live or work and the operational procedures followed at the facility.

Satellite-earth uplink stations have been analyzed and their emissions measured to determine methods to estimate potential environmental exposure levels. An empirical model has been developed, based on antenna theory and measurements, to evaluate potential environmental exposure from these systems [Reference 15]. In general, for parabolic aperture antennas with circular cross sections, the following information and equations from this model can be used in evaluating a specific system for potential environmental exposure. More detailed methods of analysis are also acceptable. For example, see References [18] and [21].

Antenna Surface. The maximum power density directly in front of an antenna (e.g., at the antenna surface) can be approximated by the following equation:

$$S_{surface} = \frac{4P}{A} \quad (11)$$

where: $S_{surface}$ = maximum power density at the antenna surface
 P = power fed to the antenna
 A = physical area of the aperture antenna

Near-Field Region. In the near-field, or Fresnel region, of the main beam, the power density can reach a maximum before it begins to decrease with distance. The extent of the near-field can be described by the following equation (D and λ in same units):

$$R_{nf} = \frac{D^2}{4\lambda} \quad (12)$$

where: R_{nf} = extent of near-field
 D = maximum dimension of antenna (diameter if circular)
 λ = wavelength

The magnitude of the on-axis (main beam) power density varies according to location in the near-field. However, the maximum value of the near-field, on-axis, power density can

be expressed by the following equation:

$$S_{nf} = \frac{16\eta P}{\pi D^2} \quad (13)$$

where: S_{nf} = maximum near-field power density
 η = aperture efficiency, typically 0.5-0.75
 P = power fed to the antenna
 D = antenna diameter

Aperture efficiency can be estimated, or a reasonable approximation for circular apertures can be obtained from the ratio of the effective aperture area to the physical area as follows:

$$\eta = \frac{\left(\frac{G\lambda^2}{4\pi} \right)}{\left(\frac{\pi D^2}{4} \right)} \quad (14)$$

where: η = aperture efficiency for circular apertures
 G = power gain in the direction of interest relative to an isotropic radiator
 λ = wavelength
 D = antenna diameter

If the antenna gain is not known, it can be calculated from the following equation using the actual or estimated value for aperture efficiency:

$$G = \frac{4\pi\eta A}{\lambda^2} \quad (15)$$

where: η = aperture efficiency
 G = power gain in the direction of interest relative to an isotropic radiator
 λ = wavelength
 A = physical area of the antenna

Transition Region. Power density in the transition region decreases inversely with distance from the antenna, while power density in the far-field (Fraunhofer region) of the antenna decreases inversely with the *square* of the distance. For purposes of evaluating RF exposure, the distance to the beginning of the far-field region (farthest extent of the transition region) can be approximated by the following equation:

$$R_{ff} = \frac{0.6 D^2}{\lambda} \quad (16)$$

where: R_{ff} = distance to beginning of far-field
 D = antenna diameter
 λ = wavelength

The transition region will then be the region extending from R_{nf} , calculated from Equation (12), to R_{ff} . If the location of interest falls within this transition region, the on-axis

$$S_t = \frac{S_{nf} R_{nf}}{R} \quad (17)$$

power density can be determined from the following equation:

where: S_t = power density in the transition region
 S_{nf} = maximum power density for near-field calculated above
 R_{nf} = extent of near-field calculated above
 R = distance to point of interest

Far-Field Region. The power density in the far-field or Fraunhofer region of the antenna pattern decreases inversely as the square of the distance. The power density in the far-field region of the radiation pattern can be estimated by the general equation discussed earlier:

$$S_{ff} = \frac{PG}{4\pi R^2} \quad (18)$$

where: S_{ff} = power density (on axis)
 P = power fed to the antenna
 G = power gain of the antenna in the direction of interest relative to an isotropic radiator
 R = distance to the point of interest

In the far-field region, power is distributed in a series of maxima and minima as a function of the off-axis angle (defined by the antenna axis, the center of the antenna and the specific point of interest). For constant phase, or uniform illumination over the aperture, the main beam will be the location of the greatest of these maxima. The on-axis power densities calculated from the above formulas represent the maximum exposure levels that the system can produce. Off-axis power densities will be considerably less.

For off-axis calculations in the near-field and in the transition region it can be assumed that, if the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point would be at least a factor of 100 (20 dB) less than the value calculated for the equivalent distance in the main beam (see Reference [15]).

For practical estimation of RF fields in the off-axis vicinity of aperture antennas, use of the antenna radiation pattern envelope can be useful. For example, for the case of an earth station in the fixed-satellite service, the Commission's Rules specify maximum allowable gain for antenna sidelobes not within the plane of the geostationary satellite orbit, such as at ground level.¹⁹ In such cases, the rules require that the gain of the antenna shall lie below the envelope defined by:

$$\begin{aligned} & \mathbf{32 - \{25\log_{10}(\theta)\} \text{ dBi} \quad \text{for } 1^\circ \leq \theta \leq 48^\circ} \\ & \text{and: } \mathbf{- 10 \text{ dBi} \quad \text{for } 48^\circ < \theta \leq 180^\circ} \end{aligned}$$

Where: θ = the angle in degrees from the axis of the main lobe
dBi = dB relative to an isotropic radiator

Use of the gain obtained from these relationships in simple far-field calculations, such as Equation 18, will generally be sufficient for estimating RF field levels in the surrounding environment, since the apparent aperture of the antenna is typically very small compared to its frontal area.

Special Antenna Models

There are various antenna types for which other models and prediction methods could be useful for evaluating the potential for exposure. To discuss models for each of the numerous types of antennas in existence would be beyond the scope of this bulletin. However, some specific cases and applications will be mentioned. In addition, a model that

¹⁹ See 47 CFR 25.209 (a)(2).

was developed for FM radio broadcast antennas is discussed in Supplement A to this bulletin.²⁰

Prediction methods have been developed for certain specialized antennas used for paging, cellular radio and personal communications services (PCS). In 1995, a study was performed for the FCC by Richard Tell Associates, Inc., that included developing prediction methodology for RF fields in the vicinity of such antennas, particularly those that may be located on rooftops (see References [29] and also [22]). In that study it was found that at distances close to these antennas a power density model based on inverse distance was more accurate than predictions based on the typical far-field equations such as Equations (3) and (4) above. In other words, in these equations the factor R could be substituted for the factor R^2 for a more realistic approximation of the true power density close to the antennas. The distance over which this relation holds appears to vary with the antenna under study, but can extend for several meters according to the Tell study.

Tell has observed that the use of a cylindrical model can be useful in evaluating RF fields near vertical collinear dipole antennas similar to those used for cellular, PCS, paging and two-way radio communications.²¹ This model can also be used in estimating near-field exposures adjacent to television and FM radio broadcast antennas where workers may be located during tower work. In general, this model is a more accurate predictor of exposure very close to an antenna where "far-field" equations, such as Equation 1, may significantly *overpredict* the RF environment. However, as one moves away from an antenna the cylindrical model becomes overly conservative and the far-field model becomes more accurate. The exact distance ("crossover point") where this occurs is not a simple value but depends on characteristics of the antenna such as aperture dimension and gain. One can determine this crossover point by calculating and plotting power densities using a far-field model and the cylindrical model described below and finding the distance where the predictions coincide.

For Tell's cylindrical model, spatially averaged plane-wave equivalent power densities parallel to the antenna may be estimated by dividing the net antenna input power by the surface area of an imaginary cylinder surrounding the length of the radiating antenna. While the actual power density will vary along the height of the antenna, the average value along its

²⁰ Additional Information for Radio and Television Broadcast Stations, Supplement A to OET Bulletin 65, Version 97-01. This supplement will be made available for downloading from the FCC RF Safety Web Site: www.fcc.gov/oet/rfsafety. Otherwise contact the FCC RF Safety Program at: (202) 418-2464.

²¹ Tell, Richard A. (1996). *EME Design and Operation Considerations for Wireless Antenna Sites*. Technical report prepared for the Cellular Telecommunications Industry Association, Washington, D.C. 20036.

length will closely follow the relation given by the following equation.

$$S = \frac{P_{net}}{2\pi Rh} \quad (19)$$

where: S = power density
 P_{net} = net power input to the antenna
R = distance from the antenna
h = aperture height of the antenna

For sector-type antennas, power densities can be estimated by dividing the net input power by that portion of a cylindrical surface area corresponding to the angular beam width of the antenna. For example, for the case of a 120-degree azimuthal beam width, the surface area should correspond to 1/3 that of a full cylinder. This would increase the power density near the antenna by a factor of three over that for a purely omni-directional antenna. Mathematically, this can be represented by Equation (20) in which the angular beam width, θ_{BW} , can be taken as the appropriate azimuthal "power dispersion" angle for a given reflector. For example, a conservative estimate could be obtained by using the 3 dB (half-power) azimuthal beam width for a given sectorized antenna.

$$S = \left(\frac{180}{\theta_{BW}} \right) \frac{P_{net}}{\pi Rh} \quad (20)$$

where: S = power density
 P_{net} = net power input to the antenna
 θ_{BW} = beam width of the antenna in degrees
R = distance from the antenna
h = aperture height of the antenna

Equation (20) can be used for any vertical collinear antenna, even omni-directional ones. For omni-directional antennas, θ_{BW} would be 360 degrees and Equation (20) reduces to the simpler Equation (19) above.

Multiple-Transmitter Sites and Complex Environments

It is common for multiple RF emitters to be co-located at a given site. Antennas are often clustered together at sites that may include a variety of RF sources such as radio and television broadcast towers, CMRS antennas and microwave antennas. The FCC's exposure guidelines are meant to apply to any exposure situation caused by transmitters regulated by

the FCC. Therefore, at multiple-transmitter sites, all significant contributions to the RF environment should be considered, not just those fields associated with one specific source. When there are multiple transmitters at a given site collection of pertinent technical information about them will be necessary to permit an analysis of the overall RF environment by calculation or computer modeling. However, if this is not practical a direct measurement survey may prove to be more expedient for assessing compliance (see Section 3 of this bulletin that deals with measurements for more information).

The rules adopted by the FCC specify that, in general, at multiple transmitter sites actions necessary to bring the area into compliance with the guidelines are the shared responsibility of all licensees whose transmitters produce field strengths or power density levels at the area in question in excess of 5% of the exposure limit (in terms of power density or the square of the electric or magnetic field strength) applicable to their particular transmitter.²² When performing an evaluation for compliance with the FCC's RF guidelines *all* significant contributors to the ambient RF environment should be considered, including those otherwise excluded from performing routine RF evaluations, and applicants are expected to make a good-faith effort to consider these other transmitters. For purposes of such consideration, significance can be taken to mean *any* transmitter producing more than 5% of the applicable exposure limit (in terms of power density or the square of the electric or magnetic field strength) at accessible locations. The percentage contributions are then added to determine whether the limits are (or would be) exceeded. If the MPE limits are exceeded, then the responsible party or parties, as described below, must take action to either bring the area into compliance or submit an EA.

Applicants and licensees should be able to calculate, based on considerations of frequency, power and antenna characteristics the distance from their transmitter where their signal produces an RF field equal to, or greater than, the 5% threshold limit. The applicant or licensee then shares responsibility for compliance in any accessible area or areas within this 5% "contour" where the appropriate limits are found to be exceeded.

The following policy applies in the case of an application for a proposed transmitter, facility or modification (not otherwise excluded from performing a routine RF evaluation) that would *cause non-compliance* at an accessible area previously in compliance. In such a case, it is the responsibility of the applicant to either ensure compliance or submit an EA if emissions from the applicant's transmitter or facility would result in an exposure level at the non-complying area that exceeds 5% of the exposure limits applicable to that transmitter or facility in terms of power density or the square of the electric or magnetic field strength.

For a renewal applicant whose transmitter or facility (not otherwise excluded from routine evaluation) contributes to the RF environment at an accessible area *not in compliance* with the guidelines the following policy applies. The renewal applicant must submit an EA if emissions from the applicant's transmitter or facility, at the area in question, result in an exposure level that exceeds 5% of the exposure limits applicable to that particular transmitter

²² See 47 C.F.R. 1.1307(b)(3), as amended.

in terms of power density or the square of the electric or magnetic field strength. In other words, although the renewal applicant may only be responsible for a fraction of the total exposure (greater than 5%), the applicant (along with any other licensee undergoing renewal at the same time) will trigger the EA process, unless suitable corrective measures are taken to prevent non-compliance before preparation of an EA is necessary. In addition, in a renewal situation if a determination of non-compliance is made, other co-located transmitters contributing more than the 5% threshold level must share responsibility for compliance, regardless of whether they are categorically excluded from routine evaluation or submission of an EA.

Therefore, at multiple-transmitter sites the various responsibilities for evaluating the RF environment, taking actions to ensure compliance or submitting an EA may lie either with a newcomer to the site, with a renewal applicant (or applicants) or with all significant users, depending on the situation. In general, an applicant or licensee for a transmitter at a multiple-transmitter site should seek answers to the following questions in order to determine compliance responsibility.

(1) New transmitter proposed for a multiple-transmitter site.

- Is the transmitter in question already categorically excluded from routine evaluation?
- If *yes*, routine evaluation of the application is not required.
- If *not excluded*, is the site in question already in compliance with the FCC guidelines?
- If *no*, the applicant must submit an EA with its application notifying the Commission of the non-complying situation, unless measures are to be taken to ensure compliance. Compliance is the responsibility of licensees of all transmitters that contribute to non-complying area(s) in excess of the applicable 5% threshold at the existing site. If the existing site is subsequently brought into compliance *without* consideration of the new applicant then the next two questions below apply.
- If *yes*, would the proposed transmitter cause non-compliance at the site in question?
- If *yes*, the applicant must submit an EA (or submit a new EA in the situation described above) with its application notifying the Commission of the potentially non-complying situation, unless measures will be taken by the applicant to ensure compliance. In this situation, it is the responsibility of the applicant to ensure compliance, since the existing site is already in compliance.
- If *no*, no further environmental evaluation is required and the applicant certifies compliance.

(2) Renewal applicant at a multiple-transmitter site

- Is the transmitter in question already categorically excluded from routine evaluation?
- If *yes*, routine evaluation of the application is not required.
- If *not excluded*, is the site in question already in compliance with the FCC guidelines?
- If *no*, the applicant must submit an EA with its application notifying the Commission of the non-complying situation, unless measures are taken to ensure compliance. Compliance is the responsibility of licensees of all transmitters that contribute to non-complying area(s) in excess of the applicable 5% threshold.
- If *yes*, no further environmental evaluation is necessary and the applicant certifies compliance.

The Commission expects its licensees and applicants to cooperate in resolving problems involving compliance at multiple-transmitter sites. Also, owners of transmitter sites are expected to allow applicants and licensees to take reasonable steps to comply with the FCC's requirements. When feasible, site owners should also encourage co-location and common solutions for controlling access to areas that may be out of compliance. In situations where disputes arise or where licensees cannot reach agreement on necessary compliance actions, a licensee or applicant should notify the FCC licensing bureau. The bureau may then determine whether appropriate FCC action is necessary to facilitate a resolution of the dispute.

The FCC's MPE limits vary with frequency. Therefore, in mixed or broadband RF fields where several sources and frequencies are involved, the fraction of the recommended limit (in terms of power density or square of the electric or magnetic field strength) incurred within each frequency interval should be determined, and the sum of all fractional contributions should not exceed 1.0, or 100% in terms of percentage. For example, consider an antenna farm with radio and UHF television broadcast transmitters. At a given location that is accessible to the general public it is determined that FM radio station X contributes $100 \mu\text{W}/\text{cm}^2$ to the total power density (which is 50% of the applicable $200 \mu\text{W}/\text{cm}^2$ MPE limit for the FM frequency band). Also, assume that FM station Y contributes an additional $50 \mu\text{W}/\text{cm}^2$ (25% of its limit) and that a nearby UHF-TV station operating on Channel 35 (center frequency = 599 MHz) contributes $200 \mu\text{W}/\text{cm}^2$ at the same location (which is 50% of the applicable MPE limit for this frequency of $400 \mu\text{W}/\text{cm}^2$). The sum of all of the percentage contributions then equals 125%, and the location is not in compliance with the MPE limits for the general public. Consequently, measures must be taken to bring the site into compliance such as restricting access to the area (see Section 4 of this bulletin on controlling exposure).

As noted above, in such situations it is the shared responsibility of site occupants to take whatever actions are necessary to bring a site into compliance. In the above case, the allocation of responsibility could be generally based on each station's percentage contribution to the overall power density at the problem location, although such a formula for allocating responsibility is not an FCC requirement, and other formulas may be used, as appropriate.

When attempting to predict field strength or power density levels at multiple transmitter sites the general equations discussed in this section of the bulletin can be used at many sites, depending on the complexity of the site. Individual contributions can often be determined at a given location using these prediction methods, and then power densities (or squares of field strength values) can be added together for the total predicted exposure level. In addition, time-averaging of exposures may be possible, as explained in Section 1 of this bulletin. For sites involving radio and television broadcast stations, the methods described in Supplement A for broadcast stations can be used in some circumstances when a site is not overly complex. Also, for wireless communications sites, some organizations have developed commercially-available software for modeling sites for compliance purposes.²³

When considering the contributions to field strength or power density from other RF sources, care should be taken to ensure that such variables as reflection and re-radiation are considered. In cases involving very complex sites predictions of RF fields may not be possible, and a measurement survey may be necessary (see Section 3 of this bulletin).

The following example illustrates a simple situation involving multiple antennas. The process for determining compliance for other situations can be similarly accomplished using the techniques described in this section and in Supplement A to this bulletin that deals with radio and television broadcast operations. However, as mentioned above, at very complex sites measurements may be necessary.

In the simple example shown in Figure 4 it is desired to determine the power density at a given location **X** meters from the base of a tower on which are mounted two antennas. One antenna is a CMRS antenna with several channels, and the other is an FM broadcast antenna. The system parameters that must be known are the total ERP for each antenna and the operating frequencies (to determine which MPE limits apply). The heights above ground level for each antenna, **H1** and **H2**, must be known in order to calculate the distances, **R1** and **R2**, from the antennas to the point of interest. The methods described in this section (and in Supplement A for FM antennas) can be used to determine the power density contributions of each antenna at the location of interest, and the percentage contributions (compared to the applicable MPE limit for that frequency) are added together as described above to determine if the location complies with the applicable exposure guidelines. If the location is accessible to the public, the general/population limits apply. Otherwise occupational/controlled limits should be used.

²³ For example, the following two U.S. companies have recently begun marketing such software: (1) Richard Tell Associates, Inc., telephone: (702) 645-3338; and (2) UniSite, telephone: (972) 348-7632.

Another type of complex environment is a site with multiple towers. The same general process may be used to determine compliance as described above, if appropriate. Distances from each transmitting antenna to the point of interest must be calculated, and RF levels should be calculated at the point of interest due to emissions from each transmitting antenna using the most accurate model. Limits, percentages and cumulative percent of the limit may then be determined in the same manner as for Figure 4. Figure 5 illustrates such a situation.

Another situation may involve a single antenna that creates significant RF levels at more than one type of location. Figure 6 illustrates such a situation where exposures on a rooftop as well as on the ground are possible. The same considerations apply here as before and can be applied to predict RF levels at the points of interest. As mentioned previously, with respect to rooftop environments, it is also important to remember that building attenuation can be expected to reduce fields inside of the building by approximately 10-20 dB.

Situations where tower climbing is involved may be complicated and may require reduction of power or shutting down of transmitters during maintenance tasks (also see Section 4 of this bulletin on controlling exposure). Climbing of AM towers involves exposure due to RF currents induced in the body of the climber, and guidelines are available for appropriate power reduction (see Supplement A, Section 1, dealing with AM broadcast stations). For FM, TV and other antennas that may be mounted on towers, the highest exposures will be experienced near the active elements of each antenna and may require shutting off or greatly reducing power when a worker passes near the elements.

The equations in this section can also be used to calculate worst-case RF levels either below or above antennas that are side-mounted on towers. In the example shown in Figure 7, a more complicated situation arises when a worker is climbing an AM tower on which are side-mounted two other antennas. In this case the safest and most conservative approach would be to consult Supplement A, Section 1, for the appropriate AM power level to use and then to ensure that the transmitters for the other antennas are shut down when the climber passes near each side-mounted antenna's elements.

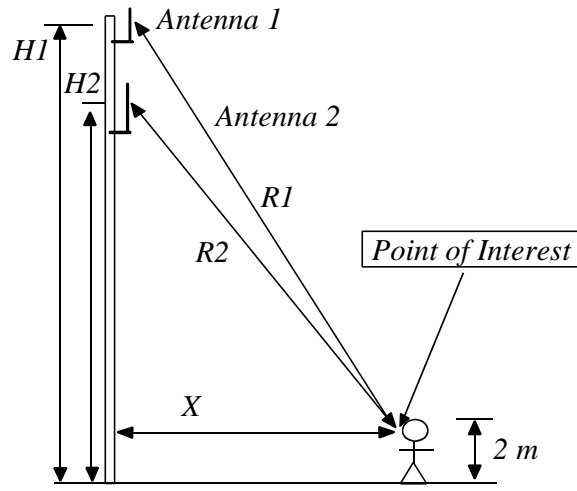


Figure 4. Single tower, co-located antennas, ground-level exposure (at 2 m).

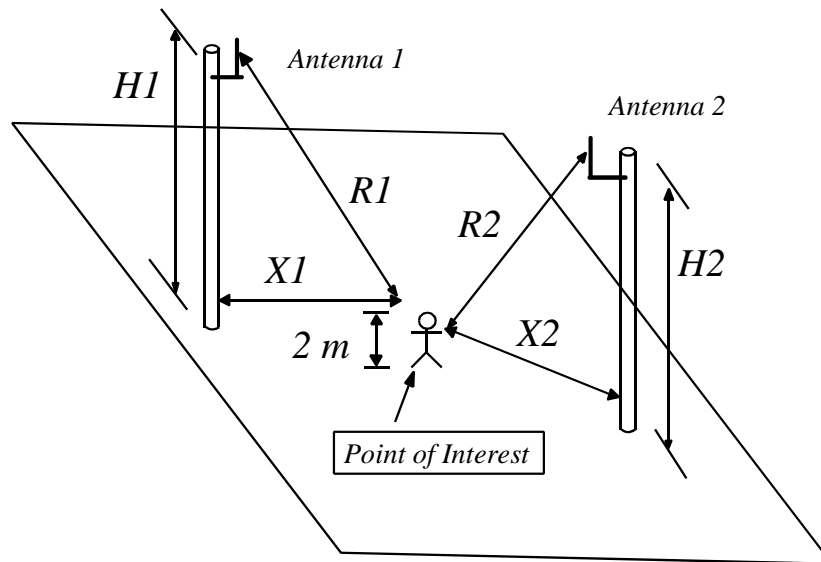


FIGURE 5. Antennas on multiple towers contributing to RF field at point of interest.

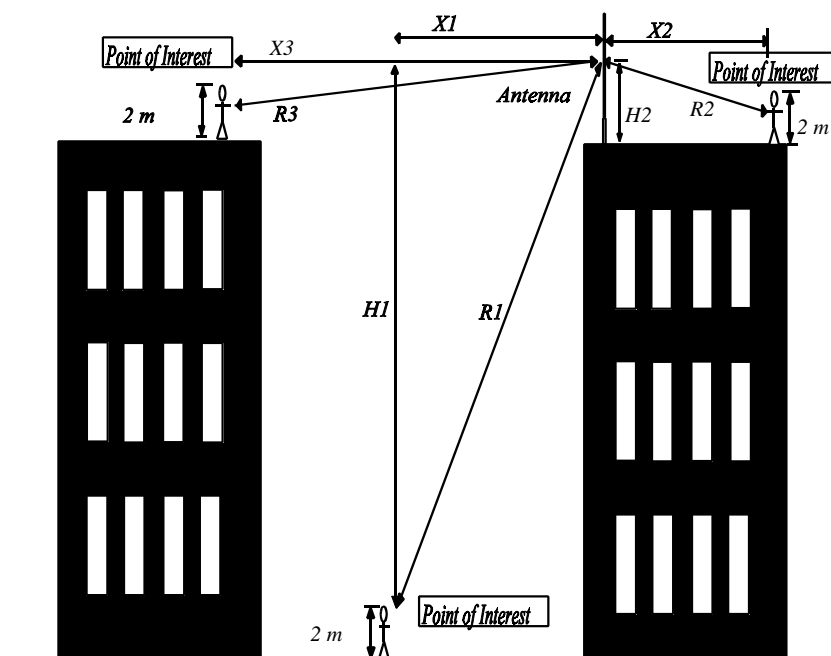


FIGURE 6. Single roof-top antenna, various exposure locations.

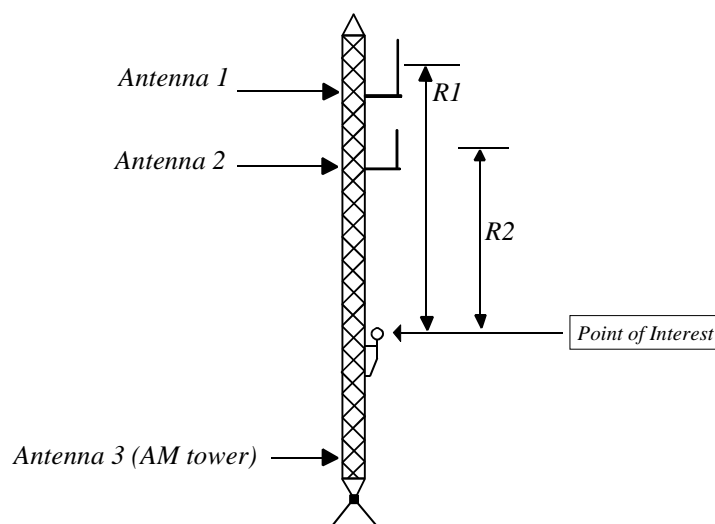


FIGURE 7. Single tower, co-located antennas, on-tower exposure.

Evaluating Mobile and Portable Devices

Portable and mobile devices present something of a special case with respect to evaluating RF exposure. The user of such a device would most likely be in the near vicinity of the RF radiator, and the predictive methods described above may not apply in all cases. Therefore, evaluation of exposure due to these devices requires special consideration. The FCC's rules for evaluating portable and mobile devices for RF compliance are contained in 47 CFR §§2.1091 and 2.1093 (see Appendix A).

The new FCC guidelines differentiate between devices according to their proximity to exposed persons. In that regard, "portable" devices are defined as those devices that are designed to be used with any part of the radiating structure of the device in direct contact with the body of the user or within 20 cm of the body of the user under normal conditions of use. This category would include such devices as hand-held cellular telephones that incorporate the radiating antenna into the handpiece. "Mobile" devices are defined by the FCC as transmitting devices designed to be used in other than fixed locations that would normally be used with radiating structures maintained 20 cm or more from the body of the user or nearby persons. In this context, the term "fixed location" means that the device is physically secured at one location and is not able to be easily moved to another location. Examples of mobile devices, as defined above, would include transportable cellular telephones ("bag" phones), cellular telephones and other radio devices that use vehicle-mounted antennas and certain other transportable transmitting devices. Transmitting devices designed to be used by consumers or workers that can be easily re-located, such as wireless devices associated with a personal computer, are considered to be mobile devices if they meet the 20 centimeter separation requirement.

Evaluation of exposure from a portable or mobile device depends on how the device is to be used. With respect to portable devices, both the 1992 ANSI/IEEE standard and the NCRP exposure criteria, upon which the FCC guidelines are based, permit devices designed to be used in the immediate vicinity of the body, such as hand-held telephones, to be excluded from compliance with the limits for field strength and power density provided that such devices comply with the limits for specific absorption rate (SAR). Therefore, portable devices, as defined by the FCC, are to be evaluated with respect to SAR not MPE limits. For most consumer-type devices, such as hand-held cellular telephones, the appropriate SAR limit is 1.6 watt/kg as averaged over any one gram of tissue, defined as a tissue volume in the shape of a cube (see Appendix A for details).

The selection of the 20-cm value for differentiating between "portable" and "mobile" devices is based on the specification in the 1992 ANSI/IEEE standard that 20 cm should be the minimum separation distance where reliable field measurements to determine adherence to MPEs can be made.²⁴ Therefore, although at closer distances a determination of SAR is

²⁴ Although ANSI/IEEE does not explicitly state a rule for determining when SAR measurements are preferable to MPE measurements, we believe that the 20 cm distance is appropriate based on Sec. 4.3(3) of ANSI/IEEE C95.1-1992.

normally a more appropriate measure of exposure, for "mobile" devices, as defined above, compliance can be evaluated with respect to MPE limits, and the generic equations of this section, such as Equations (3) and (4), can be used for calculating exposure potential.

For portable devices SAR evaluation is routinely required by the FCC prior to equipment authorization or use for the following categories: (1) portable telephones or portable telephone devices to be used in the Cellular Radiotelephone Service authorized under Part 22, Subpart H of the FCC's rules or to be used in the Private Land Mobile Radio Services for SMR systems under Part 90 of our rules; (2) portable devices to be used in the Personal Communications Services (PCS) authorized under Part 24; (3) portable devices that operate in the General Wireless Communications Services or the Wireless Communications Service authorized under Parts 26 and 27; (4) portable devices to be used for earth-satellite communication authorized under Part 25 and Part 80; and (5) portable unlicensed PCS, portable unlicensed NII and portable millimeter-wave devices authorized under Part 15 of our rules (see Appendix A for specific rule parts).

Mobile devices, as defined above, are to be evaluated with respect to the MPE limits specified in Table 1 of Appendix A (and in 47 CFR § 1.1310). Evaluation prior to equipment authorization or use is routinely required for the following mobile transmitters if the operating frequency is 1.5 GHz or below and the effective radiated power (ERP) of the station, in its normal configuration, will be 1.5 watts or greater, *or* if the operating frequency is above 1.5 GHz and the ERP is 3 watts or more: (1) mobile telephones or portable telephone devices to be used in the Cellular Radiotelephone Service authorized under Part 22 Subpart H of the FCC's rules or to be used in the Private Land Mobile Radio Services for SMR systems under Part 90 of our rules; (2) mobile devices to be used in the Personal Communications Services (PCS) authorized under Part 24; (3) mobile devices that operate in the General Wireless Communications Services or the Wireless Communications Service authorized under Parts 26 and 27; (4) mobile devices to be used for earth-satellite communication authorized under Part 25 and Part 80; and (5) unlicensed PCS, unlicensed NII and millimeter-wave mobile devices authorized under Part 15 of our rules.

Although the FCC's exposure criteria apply to portable and mobile devices in general, at this time routine evaluation for compliance is not required for devices such as "push-to-talk" portable radios and "push to talk" mobile radios used in taxicabs, business, police and fire vehicles and used by amateur radio operators. These transmitting devices are excluded from routine evaluation because their duty factors (percentage of time during use when the device is transmitting) are generally low and, for mobile radios, because their antennas are normally mounted on the body of a vehicle which provide some shielding and separation from the user. This significantly reduces the likelihood of human exposure in excess of the RF safety guidelines due to emissions from these transmitters. Duty factors associated with transmitting devices that are not "push-to-talk," such as transportable cellular telephones ("bag" phones) or cellular telephones that use vehicle-mounted antennas, would be generally higher, and these devices are subject to routine evaluation. Although we are not requiring routine evaluation of all portable and mobile devices, under Sections 1.1307(c) and 1.1307(d) of the FCC's Rules, 47 CFR 1.1307(c) and (d), the Commission reserves the right to require

evaluation for environmental significance of any device (in this case with respect to SAR or compliance with MPE limits).

The following guidelines should be used to determine the application of the exposure criteria to portable and mobile devices in general. First of all, devices may generally be evaluated based on whether they are designed to be used under occupational/controlled or general population/uncontrolled conditions. Devices that are designed specifically to be used in the workplace, such as many hand-held, two-way portable radios, would be considered as operating in an occupational/controlled environment and the applicable limits for controlled environments would apply. On the other hand, devices designed to be purchased and used primarily by consumers, such as cellular telephones and most personal communications devices, would be considered to operate under the general population/uncontrolled category, and limits for uncontrolled environments would apply. Devices that can be used in either environment would normally be required to meet uncontrolled exposure criteria.

In situations where higher exposure levels may result from unusual or inappropriate use of a device, instructional material should be provided to the user to caution against such usage. With regard to mobile devices that are not hand-held, labels and instructional material may be useful as when a minimum separation distance is desired to be maintained. For example, in the case of a cellular "bag" phone a prominent warning label as well as instructional information on minimum required distances for compliance would be an acceptable means of ensuring that the device is used safely.

With respect to evaluating portable devices, various publications are available that describe appropriate measurement techniques and methods for determining SAR for compliance purposes.²⁵ The use of appropriate numerical and computational techniques, such as FDTD analysis, may be acceptable for demonstrating compliance with SAR values. Studies have indicated that such techniques can be used to determine energy absorption characteristics in exposed subjects (e.g., see Reference [24]). However, in order for numerical techniques to be valid the basic computational algorithm and modeling of the portable device should be validated, and appropriate models of the human body should be used which will provide reasonable accurate estimates of SAR. Accurate models of the adult human body exist at the present time, but developing models of devices may be more problematic. In general, numerical device and antenna models should represent the actual device under test and should be confirmed accordingly, e.g., with appropriate techniques, analytical data, published data or far-field radiation patterns.

For purposes of evaluating compliance with localized SAR guidelines, portable devices should be tested or evaluated based on normal operating positions or conditions. Because of the location of the antenna, the antenna may be closer to the body, e.g., the head, when the

²⁵ For example, see sections of ANSI/IEEE C95.3-1992 and NCRP Report No. 119, discussed below, that describe SAR evaluation techniques. Also, see References [5], [7], [12], [13], [14], [16], [17], [23] and [24]. Other organizations are developing information on SAR evaluation procedures, and SAR evaluation services and systems are commercially available.

device is held against the left side of the head or body versus when it is held against the right side. In such cases, there will be differences in coupling to the body resulting in higher SARs when the device is held on one side rather than the other. Since various users may hold these devices in either position, both positions should be tested to determine compliance.

Industry groups and other organizations are expected to develop product performance standards and other information to ensure compliance with SAR criteria in the future. This effort will be very helpful in facilitating the provision of compliance guidelines and services to manufacturers and others. In that regard, a sub-committee sponsored by the IEEE has been recently formed to develop specific and detailed recommendations for experimental and numerical evaluation of SAR from portable devices.²⁶ FCC staff participate as members of this sub-committee, and it is expected that the FCC will be able to use the recommendations made by this group to provide future guidance on SAR evaluation.²⁷ In the meantime, the FCC expects to periodically issue statements or guidance on compliance with SAR requirements pending the issuance of any recommended protocols or guidelines from the IEEE or other organizations. Inquiries with respect to FCC requirements for SAR evaluation should be directed to the FCC's laboratory in Columbia, Maryland, telephone: (301) 725-1585.

For portable devices operating at frequencies above 6 GHz special considerations are necessary. The localized SAR criteria used by the FCC, and specified in the ANSI/IEEE 1992 standard, only apply at operating frequencies between 100 kHz and 6 GHz.²⁸ For portable devices that operate above 6 GHz (e.g., millimeter-wave devices) localized SAR is not an appropriate means for evaluating exposure. At these higher frequencies, exposure from portable devices should be evaluated in terms of power density MPE limits instead of SAR. Power density values can be either calculated or measured, as appropriate.

If power density is to be measured at these higher frequencies to show compliance of portable devices, a question arises as to an appropriate minimum distance at which to make such a measurement. The ANSI/IEEE 1992 standard specifies 20 cm as a minimum separation distance for such measurements. The guidelines delineated in NCRP No. 86 indicated that measurements should be made at least 5 cm "from any object in the field."²⁹ The more recent NCRP Report 119 seems to endorse the 20 cm value, at least for the case of

²⁶ IEEE Standards Coordinating Committee 34 (IEEE SCC34), sub-committee II. For further information contact the IEEE at 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

²⁷ It should also be noted that in February 1997 the European Committee for Electrotechnical Standardization released a CENELEC document entitled, "Considerations for Human Exposure to EMFs from Mobile Telecommunications Equipment (MTE) in the Frequency Range 30 MHz - 6 GHz." This document contains information and guidance on techniques for evaluating SAR compliance for RF devices.

²⁸ ANSI/IEEE C95.1-1992, Section 4.2.

²⁹ See Reference [20], NCRP Report No. 86 at Section 17.5.

"secondary" sources.³⁰ In some cases, for example, near an open-ended waveguide or consumer device operating at a millimeter-wave frequency, a 20 cm separation requirement from the **primary** radiating source for measurements would not be practical for determining exposure potential. Therefore, in such cases a 5 cm separation requirement can be justified to allow for evaluation of potential exposure at distances closer than 20 cm. Some research relevant to this issue has been done in the VHF band that indicates there is no practical reason why a 5 cm minimum distance cannot be used for measuring power density.³¹ Since a 5 cm separation distance is already built-in to many isotropic broadband RF probes, performing measurements at this distance is straightforward.

In view of these facts, it is appropriate to evaluate **both** mobile and portable devices that operate at frequencies above 6 GHz for compliance with FCC RF guidelines in terms of the FCC MPE limits for power density. In that regard, it is appropriate to make measurements of power density at a minimum distance of 5 cm from the radiator of a portable device to show compliance.

Section 3: MEASURING RF FIELDS

Reference Material

In some cases the prediction methods described in Section 2 of this bulletin cannot be used, and actual measurements of the RF field may be necessary to determine whether there is a potential for human exposure in excess of the MPE limits specified by the FCC. For example, in a situation such as an antenna farm, with multiple users the models discussed previously would not always be applicable. Measurements may also be desired for cases in which predictions are slightly greater or slightly less than the threshold for excessive exposure or when fields are likely to be seriously distorted by objects in the field, e.g., conductive structures.

Techniques and instrumentation are available for measuring the RF environment near broadcast and other transmitting sources. In addition, references are available which provide detailed information on measurement procedures, instrumentation, and potential problems. Two excellent references in this area have been published by the IEEE and by the NCRP. The ANSI/IEEE document (ANSI/IEEE C95.3-1992) is entitled, "Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave,"

³⁰ Reference [21], NCRP Report 119 at Section 3.3.6.

³¹ R.A. Tell, *"An Investigation of RF Induced Hot Spots and their Significance Relative to Determining Compliance with the ANSI Radiofrequency Protection Guide."* Report prepared for the National Association of Broadcasters, July 3, 1989.

(Reference [2]) and the NCRP publication (NCRP Report No. 119) is entitled, "A Practical Guide to the Determination of Human Exposure to Radiofrequency Fields" (Reference [21]). Both of these documents contain practical guidelines and information for performing field measurements in broadcast and other environments, and the FCC strongly encourages their use. Other selected references are given in the reference section of this bulletin.

Instrumentation

Instruments used for measuring radiofrequency fields may be either broadband or narrowband devices. A typical broadband instrument responds essentially uniformly and instantaneously over a wide frequency range and requires no tuning. A narrowband instrument may also operate over a wide frequency range, but the instantaneous bandwidth may be limited to only a few kilohertz, and the device must be tuned to the frequency of interest. Each type of instrument has certain advantages and certain disadvantages, and the choice of which instrument to use depends on the situation where measurements are being made.

All instruments used for measuring RF fields have the following basic components: (1) an antenna to sample the field, (2) a detector to convert the time-varying output of the antenna to a steady-state or slowly varying signal, (3) electronic circuitry to process the signal, and (4) a readout device to display the measured field parameter in appropriate units.

The antennas most commonly used with broadband instruments are either dipoles that respond to the electric field (E) or loops that respond to the magnetic field (H). Surface area or displacement-current sensors that respond to the E-field are also used. In order to achieve a uniform response over the indicated frequency range, the size of the dipole or loop must be small compared to the wavelength of the highest frequency to be measured. Isotropic broadband probes contain three mutually orthogonal dipoles or loops whose outputs are *summed* so that the response is independent of orientation of the probe. The output of the dipoles or loops is converted to a proportional steady-state voltage or current by diodes or thermocouples, so that the measured parameter can be displayed on the readout device.

As described in the first edition of this bulletin, there are certain characteristics which are desirable in a broadband survey instrument. The major ones are as follows:

- (1) The response of the instrument should be essentially isotropic, i.e., independent of orientation, or rotation angle, of the probe.
- (2) The frequency range of the instrument and the instruments response over that range should be known. Generally this is given in terms of the error of response between certain frequency limits, e.g. , ± 0.5 dB from 3 to 500 MHz.
- (3) Out-of-band response characteristics of the instrument should be specified by the manufacturer to assist the user in selecting an instrument for a particular application.

For example, regions of enhanced response, or resonance, at frequencies outside of the band of interest could result in error in a measurement, if signals at the resonant frequency(ies) are present during the measurement.

- (4) The dynamic range of the instrument should be at least ± 10 dB of the applicable exposure guideline.
- (5) The instrument's readout device should be calibrated in units that correspond to the quantity actually being measured. An electric field probe responds to E or E^2 , and a magnetic field probe responds to H or H^2 , equally well in both the near-field and far-field. However, a readout device calibrated in units of power density does not read true power density if measurements are made in the near-field. This is because under plane-wave conditions, in which E , H , and power density are related by a constant quantity (the wave impedance which, for free space, is equal to 377 ohms), do not exist in the near-field where the wave impedance is complex and generally not known. Readout devices calibrated in "power density" actually read "far-field equivalent" power density or "plane-wave equivalent" power density (see discussion of MPE limits in Section 1 of this bulletin).
- (6) The probe and the attached cables should only respond to the parameter being measured, e.g. , a loop antenna element should respond to the magnetic field and should not interact significantly with the electric field.
- (7) Shielding should be incorporated into the design of the instrument to reduce or eliminate electromagnetic interference.
- (8) There should be some means, e.g., an alarm or test switch to establish that the probe is operating correctly and that none of the elements are burned out. Also, a means should be provided to alert the user if the measured signal is overloading the device.
- (9) When the amplitude of the field is changing while measurements are being made, a "peak-hold" circuit may be useful. Such a change in amplitude could result either from variation in output from the source or from moving the probe through regions of the field that are non-uniform.
- (10) For analog-type meters, the face of the meter should be coated with a transparent, conductive film to prevent false readings due to the accumulation of static charge in the meter itself. Also, the outer surface of the probe assembly of electric-field survey instruments should be covered with a high-resistance material to minimize errors due to static charge buildup.
- (11) The instrument should be battery operated with easily replaceable or rechargeable batteries. A test switch or some other means should be provided to determine whether the batteries are properly charged. The instrument should be capable of operating

within the stated accuracy range for a time sufficient to accomplish the desired measurements without recharging or replacing the batteries.

(12) The user should be aware of the response time of the instrument, i.e., the time required for the instrument to reach a stable reading.

(13) The device should be stable enough so that frequent readjustment to zero ("rezeroing") is not necessary. If not equipped with automatic zeroing capability, devices must be zeroed with the probe out of the field, either by shielding them or turning off the RF source(s). Either method is time consuming, making stability an especially desirable feature.

(14) If the instrument is affected by temperature, humidity, pressure, etc., the extent of the effect should be known and taken into account.

(15) The sensor elements should be sufficiently small and the device should be free from spurious responses so that the instrument responds correctly to the parameter being measured, both in the near-field and in the far-field. It should be emphasized that an instrument with a readout expressed in terms of power density will only be correct in the far-field. However, the term "far-field equivalent" or "plane-wave equivalent" power density is sometimes used in this context and would be acceptable as long as its meaning is understood and it is appropriately applied to the situation of interest (see discussion in Section 1).

(16) The instrument should respond to the average (rms) values of modulated fields independent of modulation characteristics. With respect to measurements of pulsed sources such as radar transmitters, many commercially-available survey instruments cannot measure high peak-power pulsed fields accurately. In such cases, the instrument should be chosen carefully to enable fields close to the antenna to be accurately measured.

(17) The instrument should be durable and able to withstand shock and vibration associated with handling in the field or during shipping. A storage case should be provided.

(18) The accuracy of the instrument should not be affected by exposure to light or other forms of ambient RF and low-frequency electromagnetic fields.

(19) The markings on the meter face should be sufficiently large to be easily read at arm's length.

(20) Controls should be clearly labeled and kept to a minimum, and operating procedures should be relatively simple.

(21) Typical meters use high-resistance leads that can be particularly susceptible to flexure noise when measuring fields at relatively low intensities. Therefore, when a broadband isotropic meter is used for measuring power density levels that fall into the lower range of detectability of the instrument (e.g., a few $\mu\text{W}/\text{cm}^2$), the meter should exhibit low noise levels if such measurements are to have any meaning.

(22) When measuring fields in multiple-emitter environments, the ability of many commonly available RF broadband survey meters to accurately measure multiple signals of varying frequencies may be limited by how the meter sums the outputs of its diode detectors. This can lead to over-estimates of the total RF field that may be significant. Although such estimates can represent a "worst case," and are allowable for compliance purposes, users of these meters should be aware of this possible source of error.

A useful characteristic of broadband probes used in multiple-frequency RF environments is a frequency-dependent response that corresponds to the variation in MPE limits with frequency. Broadband probes having such a "shaped" response permit direct assessment of compliance at sites where RF fields result from antennas transmitting over a wide range of frequencies. Such probes can express the composite RF field as a percentage of the applicable MPEs.

Another practical characteristic of some RF field instruments is their ability to automatically determine spatial averages of RF fields. Because the MPEs for exposure are given in terms of spatial averages, it is helpful to simplify the measurement of spatially variable fields via data averaging as the survey is being performed. Spatial averaging can be achieved via the use of "data loggers" attached to survey meters or circuitry built into the meter.

Narrowband devices may also be used to characterize RF fields for exposure assessment. In contrast to broadband devices, narrowband instruments may have bandwidths of only a few hundred kilohertz or less. Narrowband instruments, such as field-strength meters and spectrum analyzers, must be tuned from frequency to frequency, and the field level at each frequency measured. Spectrum analyzers can be scanned over a band of frequencies, and the frequency and peak-amplitude information can be stored and printed for later analysis. The results of all narrowband measurements may then be combined to determine the total field.

As with broadband instruments, narrowband devices consist of basically four components: an antenna, cables to carry the signal from the antenna, electronic circuitry to process the output from the antenna and convert it to a steady-state signal proportional to the parameter being measured, and a readout device. Narrowband instruments may use various antennas, such as rods (monopoles), loops, dipoles, biconical, conical log spiral antennas or aperture antennas such as pyramidal horns or parabolic reflectors. A knowledge of the gain, the antenna factor, or the effective area for a particular antenna provides a means for determining the appropriate field parameter from a measurement of voltage or power. Cable

loss also should be taken into account. Tunable field strength meters and spectrum analyzers are appropriate narrowband instruments to use for measuring antenna terminal voltage or power at selected frequencies. Each has certain advantages and disadvantages.

Field Measurements

Before beginning a measurement survey it is important to characterize the exposure situation as much as possible. An attempt should be made to determine:

- (1) The frequency and maximum power of the RF source(s) in question, as well as any nearby sources.
- (2) Duty factor, if applicable, of the source(s).
- (3) Areas that are accessible to either workers or the general public.
- (4) The location of any nearby reflecting surfaces or conductive objects that could produce regions of field intensification ("hot spots").
- (5) For pulsed sources, such as radar, the pulse width and repetition rate and the antenna scanning rate.
- (6) If appropriate, antenna gain and vertical and horizontal radiation patterns.
- (7) Type of modulation of the source(s).
- (8) Polarization of the antenna(s).
- (9) Whether measurements are to be made in the near-field, in close proximity to a leakage source, or under plane-wave conditions. The type of measurement needed can influence the type of survey probe, calibration conditions and techniques used.

If possible, one should estimate the maximum expected field levels, in order to facilitate the selection of an appropriate survey instrument. For safety purposes, the electric field (or the far-field equivalent power density derived from the E-field) should be measured first because the body absorbs more energy from the electric field, and it is potentially more hazardous. In many cases it may be best to begin by using a broadband instrument capable of accurately measuring the total field from all sources in all directions. If the total field does not exceed the relevant exposure guideline in accessible areas, and if the measurement technique employed is sufficiently accurate, such a determination would constitute a showing of compliance with that particular guideline, and further measurements would be unnecessary.

When using a broadband survey instrument, spatially-averaged exposure levels may be determined by slowly moving the probe while scanning over an area approximately equivalent to the vertical cross-section (projected area) of the human body. An average can be estimated by observing the meter reading during this scanning process or be read directly on those meters that provide spatial averaging. Spatially averaging exposure is discussed in more detail in the ANSI/IEEE and NCRP documents referenced above. A maximum field reading may also be desirable, and, if the instrument has a "peak hold" feature, can be obtained by observing the peak reading according to the instrument instructions. Otherwise, the maximum reading can be determined by simply recording the peak during the scanning process.

The term "hot spots" has been used to describe locations where peak readings occur. Often such readings are found near conductive objects, and the question arises as to whether it is valid to consider such measurements for compliance purposes. According to the ANSI C95.3 guidelines (Reference [2]) measurements of field strength to determine compliance are to be made, "at distances 20 cm or greater from any object." Therefore, as long as the 20 cm criterion is satisfied, such peak readings should be considered as indicative of the field *at that point*. However, as far as *average* exposure is concerned such localized readings may not be relevant if accessibility to the location is restricted or time spent at the location is limited (see Section 4 of this bulletin on controlling exposure). It should be noted that most broadband survey instruments already have a 5 cm separation built into the probe.

In many situations there may be several RF sources. For example, a broadcast antenna farm or multiple-use tower could have several types of RF sources including AM, FM, and TV, as well as CMRS and microwave antennas. Also, at rooftop sites many different types of CMRS antennas are commonly present. In such situations it is generally useful to use both broadband and narrowband instrumentation to fully characterize the electromagnetic environment. Broadband instrumentation could be used to determine what the overall field levels appeared to be, while narrowband instrumentation would be required to determine the relative contributions of each signal to the total field if the broadband measurements exceed the most restrictive portion of the applicable MPEs. The "shaped" probes mentioned earlier will also provide quantification of the total field in terms of percentage of the MPE limits.

In cases where personnel may have close access to intermittently active antennas, for example at rooftop locations, measurement surveys should attempt to minimize the uncertainty associated with the duty cycle of the various communications transmitters at the site to arrive at a conservative estimate of maximum possible exposure levels.

At broadcast sites it is important to determine whether stations have auxiliary, or stand-by, antennas at a site in addition to their main antennas. In such cases, either the main antenna or the auxiliary antenna, which may be mounted lower to the ground, may result in the highest RF field levels in accessible areas, and contributions from both must be properly evaluated.

At frequencies above about 300 MHz it is usually sufficient to measure only the electric field (E) or the mean-squared electric field. For frequencies equal to or less than 30

MHz, for example frequencies in the AM broadcast band, measurements for determining compliance with MPE limits require independent measurement of **both** E field and the magnetic field (H). For frequencies between 30 and 300 MHz it may be possible through analysis to show that measurement of only one of the two fields, not both, is sufficient for determining compliance. Further discussion of this topic can be found in Sections 4.3(2) and 6.6 of Reference [1]. At sites with higher frequency sources, such as UHF-TV stations, only E-field measurements should be attempted since the loop antennas used in H-field probes are subject to out-of-band resonances at these frequencies.

In many situations a relatively large sampling of data will be necessary to spatially resolve areas of field intensification that may be caused by reflection and multipath interference. Areas that are normally occupied by personnel or are accessible to the public should be examined in detail to determine exposure potential.

If narrowband instrumentation and a linear antenna are used, field intensities at three mutually orthogonal orientations of the antenna must be obtained at each measurement point. The values of E^2 or H^2 will then be equal to the sum of the squares of the corresponding, orthogonal field components.

If an aperture antenna is used, unless the test antenna responds uniformly to all polarizations in a plane, e.g., a conical log-spiral antenna, it should be rotated in both azimuth and elevation until a maximum is obtained. The antenna should then be rotated about its longitudinal axis and the measurement repeated so that both horizontally and vertically polarized field components are measured. It should be noted that when using aperture antennas in reflective or near-field environments, significant negative errors may be obtained.

When making measurements, procedures should be followed which minimize possible sources of error. For example, when the polarization of a field is known, all cables associated with the survey instrument should be held perpendicular to the electric field in order to minimize pickup. Ideally, non-conductive cable, e.g., optical fiber, should be used, since substantial error can be introduced by cable pick-up.

Interaction of the entire instrument (probe plus readout device) with the field can be a significant problem below approximately 10 MHz, and it may be desirable to use a self-contained meter or a fiber-optically coupled probe for measuring electric field at these frequencies. Also, at frequencies below about 1 MHz, the body of the person making the measurement may become part of the antenna, and error from probe/cable pickup and instrument/body interaction may be reduced by supporting the probe and electronics on a dielectric structure made of wood, styrofoam, etc. In all cases, it is desirable to remove all unnecessary personnel from an area where a survey is being conducted in order to minimize errors due to reflection and field perturbation.

In areas with relatively high fields, it is a good idea to occasionally hold the probe fixed and rotate the readout device and move the connecting cable while observing the meter reading. Alternatively, cover the entire sensor of the probe with metal foil and observe the

meter reading. Any significant change usually indicates pickup in the leads and interference problems. When a field strength meter or spectrum analyzer is used in the above environments, the antenna cable should occasionally be removed and replaced with an impedance matched termination. Any reading on the device indicates pickup or interference.

As noted previously, substantial errors may be introduced due to zero drift. If a device is being used which requires zeroing, it should frequently be checked for drift. This should be done with the probe shielded with metal foil, with the probe removed from the field or, ideally, with the source(s) shut off.

With regard to compliance with the FCC's guidelines in mixed or broadband fields where several sources and frequencies are involved, the fraction or percentage of the recommended limit for power density (or square of the field strength) incurred within each frequency interval should be determined, and the sum of all contributions should not exceed 1.0 or 100% (see discussion of this topic in Section 1 of this bulletin). As mentioned before, probes with "shaped" responses may be useful in these environments.

Section 4: CONTROLLING EXPOSURE TO RF FIELDS

Public Exposure: Compliance with General Population/Uncontrolled MPE Limits

Studies have indicated that the majority of the United States population is normally exposed to insignificant levels of RF radiation in the ambient environment (e.g. see References [22] and [30]). However, there are some situations in which RF levels may be considerably higher than the median background, and in those cases preventive measures may have to be taken to control exposure levels.

As discussed in Section 1 of this bulletin (also see Appendix A), the FCC's guidelines for exposure incorporate two tiers of limits, one for conditions under which the public may be exposed ("general population/uncontrolled" exposure) and the other for exposure situations usually involving workers ("occupational/controlled" exposure). Exposure problems involving members of the general public are generally less common than those involving persons who may be exposed at their place of employment, due to the fact that workers may be more likely to be in close proximity to an RF source as part of their job. However, if potential exposure of the general public is a problem there are several options available for ensuring compliance with the FCC RF guidelines.

In general, in order for a transmitting facility or operation to be out of compliance with the FCC's RF guidelines an area or areas where levels exceed the MPE limits must, first of all, be in some way *accessible* to the public or to workers. This should be obvious, but there is often confusion over an *emission* limit, e.g., a limit on field strength or power density

at a specified distance from a radiator that always applies, and an *exposure* limit, that applies anywhere people may be located. The FCC guidelines specify exposure limits not emission limits, and that distinction must be emphasized. This is why the accessibility issue is key to determining compliance. The MPE limits indicate levels above which people may not be safely exposed regardless of the location where those levels occur. When accessibility to an area where excessive levels is appropriately restricted, the facility or operation can certify that it complies with the FCC requirements.

Restricting access is usually the simplest means of controlling exposure to areas where high RF levels may be present. Methods of doing this include fencing and posting such areas or locking out unauthorized persons in areas, such as rooftop locations, where this is practical.³² There may be situations where RF levels may exceed the MPE limits for the general public in remote areas, such as mountain tops, that could conceivably be accessible but are not likely to be visited by the public. In such cases, common sense should dictate how compliance is to be achieved. If the area of concern is properly marked by appropriate warning signs, fencing or the erection of other permanent barriers may not be necessary.³³

In some cases, the time-averaging aspects of the exposure limits may be used by placing appropriate restrictions on occupancy in high-field areas. However, such restrictions are often not possible where continuous exposure of the public may occur. In general, time averaging of exposures is usually more practical in controlled situations where occupational exposure is the only issue.

Although restricting access may be the simplest and most cost-effective solution for reducing public exposure, other methods are also available. Such methods may be relevant for reducing exposure for both the general public and for workers. For example, modifications to antennas, elevating antennas on roof-top installations or incorporation of appropriate shielding can reduce RF fields in locations accessible to the public or to workers.

³² Standard radiofrequency hazard warning signs are commercially available from several vendors. They incorporate the format recommended by the American National Standards Institute (ANSI) as specified in ANSI C95.2-1982 (Reference [3]). Although the ANSI format is recommended, it is not mandatory. Complaints have been received concerning the lack of color durability in outdoor environments of the yellow triangle specified by ANSI. In that regard, long-lasting and clearly visible symbols are more important than the exact color used, and the use of the ANSI format with more durable colors may be more practical in certain environments. When signs are used, meaningful information should be placed on the sign advising of the potential for high RF fields. In some cases, it may be appropriate to also provide instructions to direct individuals as to how to work safely in the RF environment of concern. U.S. vendors of RF warning and hazard signs include: National Association of Broadcasters (800-368-5644), EMED Co., Inc. (800-442-3633) and Richard Tell Associates (702-645-3338).

³³ Regarding this issue, the Commission's Mass Media Bureau released a Public Notice, on January 28, 1986, entitled, "Further Guidance for Broadcasters Regarding Radiofrequency Radiation and the Environment," (No. 2278). This Notice lists several typical exposure situations around broadcast sites and explains what is expected of broadcast licensees and applicants with respect to ensuring compliance with the FCC's RF guidelines. This Notice may be useful as guidance for other antenna sites. A summary of the major points of the 1986 Public Notice are included as Appendix B of this bulletin. Also, another Public Notice, dealing primarily with occupational exposure, was issued by the Mass Media Bureau on August 19, 1992 (No. 24479).

With regard to antennas used for FM broadcast stations, the EPA found that there are several corrective measures that may be taken to reduce ground-level field strength and power density (Reference [11]). Some of these findings may also be relevant to other similar types of antenna systems. EPA's examination of measured elevation patterns for several different types of FM antennas has shown that some antennas direct much less radiation downward than others. Therefore, in some cases a change of antenna may be an appropriate way to reduce ground-level fields below a given level.

A more expensive, but also effective, approach for FM antennas involves modifying the array pattern by reducing the spacing between the radiating elements. The pattern of an FM antenna is the product of the element pattern and the array pattern. FM antennas typically use one-wavelength spacing between elements. Because the wave from each element adds in phase with all the other elements, at points directly beneath the elements the array pattern results in downward radiation that can be significant and, in the case of dipole elements, could equal that in the main beam. If the spacing is reduced to one-half wavelength spacing (for an antenna with an even number of bays), each wave will have a counterpart which is out-of-phase. This will result in a significant reduction in the energy radiated toward the ground.

The disadvantage of this method is that the shorter aperture that will occur with one-half wavelength spacing reduces the overall gain of the antenna. To maintain the original gain of the antenna, the number of elements (bays) has to be increased and, usually, doubled. Alternatively, the spacing between elements could be reduced so that waves from element (n) and from element $(N/2 + n)$ are exactly out of phase, where n is a particular element in an array with a total of N bays.

Use of the latter method would result in a smaller increase in the total number of bays that would be necessary. However, EPA has noted that feeding such an array would be more difficult since the length of the transmission line between bays determines phasing. For one-half wave spacing, EPA suggests that criss-crossing the transmission line or turning alternate elements upside down will yield proper phasing.

The EPA's report (Reference [11]) contains a table showing suggested interbay spacings required to reduce downward radiation in the array pattern of FM antennas. Unfortunately, the optimum spacing may differ for different types of antennas. Coupling effects may occur at spacings of less than one wavelength that are not easy to predict theoretically. EPA has studied this problem, and Reference [11] also contains figures showing the effects of altering spacing for three types of FM antenna elements.

Another possible method for reducing downward radiation that has been suggested involves using 1.5-wavelength spacing between elements. This method reportedly results in little significant change in antenna gain.

Other actions that could be taken to reduce the potential for excessive exposure would be raising the height of an FM or TV antenna or relocating a broadcast tower. However, such

actions would have to take into account other factors including signal coverage, land use limitations, and air traffic safety.

In the case of television broadcast antennas, the EPA identified two methods for reducing potential exposure, besides the obvious method of restricting access discussed above. The first measure that might be taken, as with FM antennas, would be a change of antenna. EPA verified, for example, that arrays for VHF-TV antennas can be designed to minimize downward radiation to as little as 7% of the main beam field. However, such antennas apparently are at least twice as expensive as standard antennas. Antennas used for UHF-TV have very high gain in the main beam and radiate relatively little directly down toward the ground. Therefore, these antennas already are designed for minimum downward radiation. The remaining option for both VHF-TV and UHF-TV antennas would be an increase in antenna height above ground. However, this could involve the same difficulties as discussed above with regard to FM broadcast facilities.

With respect to AM radio broadcast stations, monopole antennas are used for transmissions. The MPE limits in the AM broadcast band (see Appendix A) are given in terms of electric and magnetic field strength, since significant exposures always occur in the near-field of these antenna systems. Electric and magnetic field strengths near monopole antennas decrease rapidly with increasing distance, and normally the MPE limits can only be exceeded very close-in to these antennas. Therefore, exposure problems due to AM radio antennas are usually those involving workers or others who have access to the immediate vicinity of these antennas (see discussion below).

Occupational Exposure: Compliance with Occupational/Controlled MPE Limits

Exposure to RF fields in the workplace or in other controlled environments usually presents different problems than does exposure of the general public. For example, with respect to a given RF transmitting facility, a worker at that facility would be more likely to be close to the radiating source than would a person who happens to live nearby. Although restricting access to high RF field areas is also a way to control exposures in such situations, this may not always be possible. In some cases a person's job may require him or her to be near an RF source for some part of the workday. Depending on the level and time of exposure this may present a problem with respect to compliance with the MPE limits.

In general, a locked rooftop or other appropriately restricted area that is only accessible to workers who are "aware of" and "exercise control over" their exposure would meet the criteria for occupational/controlled exposure, and protection would be required at the applicable occupational/controlled MPE limits for those individuals who have access to the rooftop. Persons who are only "transient" visitors to the rooftop, such as air conditioning technicians, etc., could also be considered to fall within the occupational/controlled criteria as long as they also are "made aware" of their exposure and exercise control over their exposure (see Appendix A for definitions of exposure tiers and MPE limits).

As explained in Section 1 of this bulletin, the MPE limits adopted by the FCC are *time-averaged* exposure limits. This means that the exposure duration should be taken into account when evaluating a given exposure situation, and this is especially relevant for cases of occupational/controlled exposure. For example, a person walking into an area where RF fields exceed the *absolute* MPE limit (in terms of field strength or power density) might not exceed the *time-averaged* MPE limit as long as the exposure was for an appropriately short period of time (relative to the time-averaging interval). However, if that person were to remain in the area for an extended period it is more probable that the time-averaged limit would be exceeded. Therefore, in order to comply with the FCC's guidelines, in some situations it may be necessary to limit exposure in certain areas to specific periods of time. For example, in workplace situations where extended maintenance tasks must be performed in areas where RF fields exceed MPE limits, the work may have to be divided up and carried out during several intervals of time so that the time-averaged exposure during each interval is acceptable. The actual exposure time allowed during any given interval would have to be determined by use of the appropriate averaging time specified in the guidelines (six-minutes for occupational exposure) as explained in Section 1.

In addition to time-averaging, other means are available for controlling exposures in occupational or controlled environments. These include reducing or shutting off power when work is required in a high RF area, switching to an auxiliary transmitter (if available) while work on a main system is in progress or incorporating appropriate shielding techniques to reduce exposure.

In multiple-transmitter environments, reducing power or RF shielding may be especially important for allowing necessary work procedures to be carried out. For example, on-tower exposures due to nearby co-located transmitting sources may be more significant when work on another station's tower is required. In such complex environments power reduction agreements may often be necessary to ensure that all licensees are aware of the potential for their station to expose other individuals at the site and site occupants are generally jointly responsible for compliance with FCC guidelines (see discussion of multiple-transmitter sites in Section 2 of this bulletin).

Although reduction of power at broadcasting and other telecommunications sites is one approach to reducing personnel exposure, this may not always be possible. For example, measurements have shown that relatively high RF fields may exist in the immediate vicinity of high-powered antennas such as those used at FM broadcast stations (Reference [25]). If power reduction or other measures are not practical, alternative means for protecting personnel from excessive exposure may be necessary when access to these areas is required. In such instances, the use of radiofrequency protective clothing may facilitate compliance with RF exposure guidelines even in the presence of intense RF fields.

Radiofrequency protective clothing has become commercially available in recent years that appears to effectively attenuate fields over a broad frequency band. This clothing has been manufactured into RF protective suits that cover the entire body of the user and allow him or her to perform maintenance and other procedures in the presence of RF fields that may

exceed MPE limits. A recent study performed for the FCC by Richard Tell Associates, Inc., concluded that if properly used by appropriately trained personnel, and with adequate coupling to ground potential, RF protective suits can provide significant reduction in whole-body RF absorption (Reference [29]).

Recently, direct measurements of reduction in SAR afforded by one RF protective suit were completed using a full-size human phantom filled with a dielectric fluid having the RF absorption characteristics of biological tissue.³⁴ The SAR was determined by scanning the interior of the body of the phantom with a robotically controlled miniature, isotropic electric-field probe with and without the suit covering the phantom. Near-field exposure conditions were duplicated at frequencies of 150 MHz, 450 MHz and 835 MHz. The measurement results supported the contention that the protective suit provides a nominal minimum reduction in SAR of 10 times or more. These measurements also were consistent with measurement data obtained by the Deutsche Telekom Technologiezentrum (German Telekom).³⁵

Another observation from the tests performed by Tell is that the peak SAR in the unprotected head of the phantom clothed with the protective suit did not reach the SAR limit of 8 W/kg (localized partial-body exposure limit for occupational/controlled environments) until the 150-MHz near-field exposure was 23 times the most restrictive whole-body averaged MPE limit of 1.0 mW/cm². At 450 MHz, the maximum field incident on the unprotected head was found to be more than 11 times the applicable MPE limit of 1.5 mW/cm², and, at 835 MHz, more than 3 times the MPE limit of 2.8 mW/cm². Such data suggest that, at least in some environments, complete coverage of the body may not be necessary for compliance with MPE limits.

In general, the use of RF protective clothing may be considered an acceptable mitigation technique for occupational exposures as long as sufficient precautions are taken to comply with all of the clothing manufacturer's recommendations and caveats and to ensure that use of the clothing is confined to RF environments for which it is designed in terms of RF field intensity and frequency range. As with any personal protective equipment, RF protective clothing should be considered as a method of choice only when other engineering or administrative controls cannot be used to reduce exposure or are otherwise impractical. Those employing or supervising the wearer should ensure that the wearer has full knowledge of the proper use and limitations of the protective clothing being used. Also, users should be knowledgeable of the approximate RF environment before spending a prolonged period of time in areas where RF fields are believed to significantly exceed MPE limits. Users of RF protective clothing are cautioned that, in addition to evaluating RF field intensity and frequency considerations, they should routinely visually inspect the clothing material for

³⁴ Tell, Richard A. (1996). *SAR Evaluation of the Naptex™ Suit for Use in the VHF and UHF Telecommunications Bands*. Presented at the International RF Safety Workshop, Schwangau, Germany, September 25-26.

³⁵ Heinrich, W. (1996). *Test Method for Determining the Attenuation of RF-protective Clothing*. Presented at the International RF Safety Workshop, Schwangau, Germany, September 24-26.

indications of substantial wear, such as tears and rips, that may reduce the clothing's effectiveness in reducing exposure. When users are climbing towers, special caution is advised regarding possible safety hazards from RF shocks and burns, trip hazards, decreased mobility/agility and reduced visibility (if a protective hood is worn) that may occur while climbing.

In addition to the issue of protective clothing, Tell's 1995 study for the FCC investigated the use of RF personal monitors that have become commercially available in recent years. These monitors are warning devices that are worn by the user and alert him or her by an audible or visible signal to the presence of RF fields that approach the MPE limits for occupational/controlled exposure. The Tell study concluded that such devices can act as reliable RF detectors and the device tested generally responded in accordance with the manufacturer's specifications. Such devices could be especially useful in areas where multiple transmitters are located and it may not be easy or possible to predict the presence of high RF fields. Work procedures could be instituted requiring the wearer of such a device to leave an area or take other precautions when the device alerts that an RF field approaching the MPE limit is present. These monitors can be a valuable component of an RF safety program. However, they should be viewed only as warning devices and should not be viewed as protective devices.

For workers who must occupy areas near AM broadcast antennas, MPE limits are normally only exceeded very close to an antenna. Even for a 50 kW transmitter, distances from an antenna of less than fifteen meters are required before field strengths are likely to approach the FCC limits (References [26] and [33]). For multiple-tower arrays the spacing between adjacent antennas would not be less than 35 meters, so that, as one antenna is approached, the contribution of field strength from other antennas in the array would decrease to relatively insignificant levels. However, if work on or immediately adjacent to a tower is required it may be necessary to designate zones within which a worker may remain for specified periods of time appropriate for compliance with the FCC limits.

Tuning circuits for AM broadcast antennas have been identified as a source of locally intense magnetic fields (Reference [31]). These magnetic fields decrease rapidly with distance from the tuning circuits but should be carefully considered when evaluating exposure very near the base of AM towers or at other locations where such coils may be located. It should be possible to locate the tuning circuits in such a way as to greatly reduce the potential for exposures exceeding the FCC magnetic field limits. For example, separating the circuits from normally accessible areas by a few meters should provide sufficient protection. Time-averaging exposure near such coils is another method for complying with the MPE limits.

Probably the most common means by which workers at AM radio stations may be exposed in excess of the FCC exposure guidelines occurs when persons must climb actively transmitting AM antennas to perform maintenance tasks. Measurement surveys and studies conducted by the FCC and the EPA have clearly indicated that significant RF currents exist in the body of a person climbing such a tower (References [6], [27], [28] and [32]). As addressed by the 1992 ANSI/IEEE standard, such currents can cause significant levels of RF

absorption in the body that can be well in excess of allowable SAR thresholds (see discussion in Section 1 of this bulletin).

Although the FCC RF exposure guidelines did not specifically adopt limits on RF body currents, evaluation of such currents is the only practical means to control exposure of persons climbing transmitting AM radio towers. The FCC and EPA studies referenced above include data and models that allow a correlation to be made between the power fed into an AM antenna and the potential current that will be induced in the body of a person climbing the antenna. This current can be correlated with the appropriate limit on whole-body absorption specified by the FCC's guidelines and thereby can be used as a guideline for the appropriate power reduction that an AM station must undertake when a person is on a tower. Further information and guidance on controlling such exposures can be found in Supplement A to this bulletin that is designed for radio and television broadcast applications.

With regard to maintenance of FM and TV broadcast transmitters and antennas, two situations are of particular interest and should be noted. Because currents and voltages in power amplifier cabinets can be lethal, it is common practice that cabinet doors be closed when the transmitter is on. However, it may not be recognized that at multiple station locations high RF field strengths can be encountered even when the transmitter being worked on is completely shut down. This is because the antenna for a particular station is likely to pick up high levels of energy from other stations. That energy can be conducted to the final amplifier cubicle and produce high field strengths and high voltages in the vicinity of the cubicle. Therefore, if measurements are made in a multistation environment this factor should be evaluated. If such induced field strength levels are found to be a problem, it should be possible to reduce them to acceptable levels by either opening the RF transmission line leading to the antenna or by bypassing the center conductor to ground of the coaxial line wherever access can be conveniently achieved.

With regard to protecting personnel at paging and cellular antenna sites, Motorola, in association with Richard Tell Associates, Inc., has developed a video for electromagnetic energy awareness that is focused on wireless telecommunications service providers. Although this video was originally produced for Motorola's use and is copyrighted, Motorola has decided to make this video commercially available to other interested industrial users.³⁶ Also, as mentioned earlier, software has been developed by various organizations for use in estimating RF levels and ensuring compliance at transmitter sites, particularly rooftop sites used for personal wireless, cellular and paging services.³⁷

³⁶ The title of the video is: "EME Awareness for Antenna Site Safety," ©Motorola, 1996. Copies are available in the U.S.A. from Stephen Tell Productions (702-396-5912), or from Narda Microwave Corporation, (516) 231-1700 (Narda Part No. 42929000).

³⁷ See footnote 23.

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APPENDIX A

SUMMARY OF RF EXPOSURE GUIDELINES

This appendix summarizes the policies, guidelines and requirements that were adopted by the FCC on August 1, 1996, amending Part 1 of Title 47 of the Code of Federal Regulations, and further amended by action of the Commission on August 25, 1997 (see 47 CFR Sections 1.1307(b), 1.1310, 2.1091 and 2.1093, as amended). Commission actions granting construction permits, licenses to transmit or renewals thereof, equipment authorizations or modifications in existing facilities, require the preparation of an Environmental Assessment (EA), as described in 47 CFR Section 1.1311, if the particular facility, operation or transmitter would cause human exposure to levels of radiofrequency (RF) electromagnetic fields in excess of these limits. For exact language, see the relevant FCC rule sections.

FCC implementation of the new guidelines for mobile and portable devices became effective August 7, 1996. For other applicants and licensees a transition period was established before the new guidelines would apply. With the exception of the Amateur Radio Service, the date established for the end of the transition period is October 15, 1997. Therefore, the new guidelines will apply to applications filed on or after this date. For the Amateur Service only, the new guidelines will apply to applications filed on or after January 1, 1998.

Summary of Station and Transmitter Requirements

Applications to the Commission for construction permits, licenses to transmit or renewals thereof, equipment authorizations or modifications in existing facilities must contain a statement or certification confirming compliance with the limits unless the facility, operation, or transmitter is categorically excluded from routine evaluation, as discussed below. Technical information showing the basis for this statement must be submitted to the Commission upon request.

The FCC-adopted limits for Maximum Permissible Exposure (MPE) are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, Sections 17.4.1, 17.4.1.1, 17.4.2 and 17.4.3. Copyright NCRP, 1986, Bethesda, Maryland 20814. In the frequency range from 100 MHz to 1500 MHz, exposure limits for field strength and power density are also generally based on the MPE limits found in Section 4.1 of , "IEEE Standard for Safety

Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992, Copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017, and approved for use as an American National Standard by the American National Standards Institute (ANSI).

The FCC's MPE limits for field strength and power density are given in Table 1 (and in 47 CFR § 1.1310). Figure 1 is a graphical representation of the limits for plane-wave (far-field) equivalent power density versus frequency. The FCC's limits are generally applicable to *all* facilities, operations and transmitters regulated by the Commission, and compliance is expected with the appropriate guidelines. However, *routine* determination of compliance with these exposure limits (routine environmental evaluation), and preparation of an EA if the limits are exceeded, is required only for facilities, operations and transmitters that fall into the categories listed in Table 2, or those specified below under the headings "mobile," "unlicensed" or "portable" devices. All other facilities, operations and transmitters are categorically excluded from routine evaluation or preparing an EA for RF emissions, except that the Commission may, on its own merits or as the result of a petition, complaint or inquiry, require RF environmental evaluation of transmitters or facilities even though they are otherwise excluded [see 47 CFR Sections 1.1307(c) and (d)].

For purposes of Table 2, the term "building-mounted antennas" means antennas mounted in or on a building structure that is occupied as a workplace or residence. The term "power" in column 2 of Table 2 refers to total operating power of the transmitting operation in question in terms of effective radiated power (ERP), equivalent isotropically radiated power (EIRP), or peak envelope power (PEP), as defined in 47 CFR. § 2.1. For the case of the Cellular Radiotelephone Service, 47 CFR § 22, Subpart H, the Personal Communications Service, 47 CFR § 24, and Specialized Mobile Radio Service, 47 CFR § 90, the phrase "total power of all channels" in column 2 of Table 2 means the sum of the ERP or EIRP of all co-located simultaneously operating transmitters owned and operated by a single licensee.

When applying the criteria of Table 2, radiation in all directions should be considered. For the case of transmitting facilities using sectorized transmitting antennas, applicants and licensees should apply the criteria to all transmitting channels in a given sector, noting that for a highly directional antenna there is relatively little contribution to ERP or EIRP summation for other directions.

For purposes of calculating EIRP of an MDS station, the power level refers to the cumulative EIRP of all channels. Further, this power limit assumes conventional NTSC transmissions with 10% aural power, and refers to peak visual power. MDS stations employing other than NTSC transmissions, e.g., digital transmissions, must apply the appropriate NTSC peak visual to average power conversion factor for their modulation scheme in order to determine whether the EIRP power criteria is exceeded.

In general, as specified in 47 C.F.R. 1.1307(b), as amended, when the FCC's guidelines are exceeded *in an accessible area* due to the emissions from multiple fixed transmitters the following policy applies. Actions necessary to bring the area into compliance

with the guidelines are the shared responsibility of *all* licensees whose transmitter's contribution to the RF environment *at the non-complying area* exceeds 5% of the exposure limit (that applies to their particular transmitter) in terms of power density or the square of the electric or magnetic field strength. This applies regardless of whether such transmitters would, by themselves, normally be excluded from performing a routine environmental evaluation. Owners of transmitter sites are expected to allow applicants and licensees to take reasonable steps to comply with the FCC's requirements and, where feasible, should encourage co-location of transmitters and common solutions for controlling access to areas where the RF exposure limits might be exceeded.

The following policy applies in the case of an application for a proposed transmitter, facility or modification (not otherwise excluded from performing a routine RF evaluation) that would *cause non-compliance* at an accessible area previously in compliance. In such a case, it is the responsibility of the applicant to submit an EA if emissions from the applicant's transmitter or facility would cause non-compliance at the area in question. However, this applies only if the applicant's transmitter causes exposure levels at the area in question that exceed 5% of the exposure limits applicable to that particular transmitter in terms of power density or the square of the electric or magnetic field strength.

For a renewal applicant whose transmitter or facility (not otherwise excluded from routine evaluation) contributes to the RF environment at an accessible area *not in compliance* with the guidelines the following policy applies. The renewal applicant must submit an EA if emissions from the applicant's transmitter or facility, at the area in question, result in exposure levels that exceed 5% of the exposure limits applicable to that particular transmitter in terms of power density or the square of the electric or magnetic field strength. In other words, although the renewal applicant may only be responsible for a fraction of the total exposure (greater than 5%), the applicant (along with any other licensee undergoing renewal at the same time) will trigger the EA process, unless suitable corrective measures are taken to prevent non-compliance before an EA is necessary. In addition, in a renewal situation if a determination of non-compliance is made, other co-located transmitters contributing more than the 5% threshold level must share responsibility for compliance, regardless of whether they are categorically excluded from routine evaluation or submission of an EA.

Table 1. LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)**(A) Limits for Occupational/Controlled Exposure**

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f ²)*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f ²)*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

f = frequency in MHz

*Plane-wave equivalent power density

NOTE 1: **Occupational/controlled** limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: **General population/uncontrolled** exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

Figure 1. *FCC Limits for Maximum Permissible Exposure (MPE)*
Plane-wave Equivalent Power Density

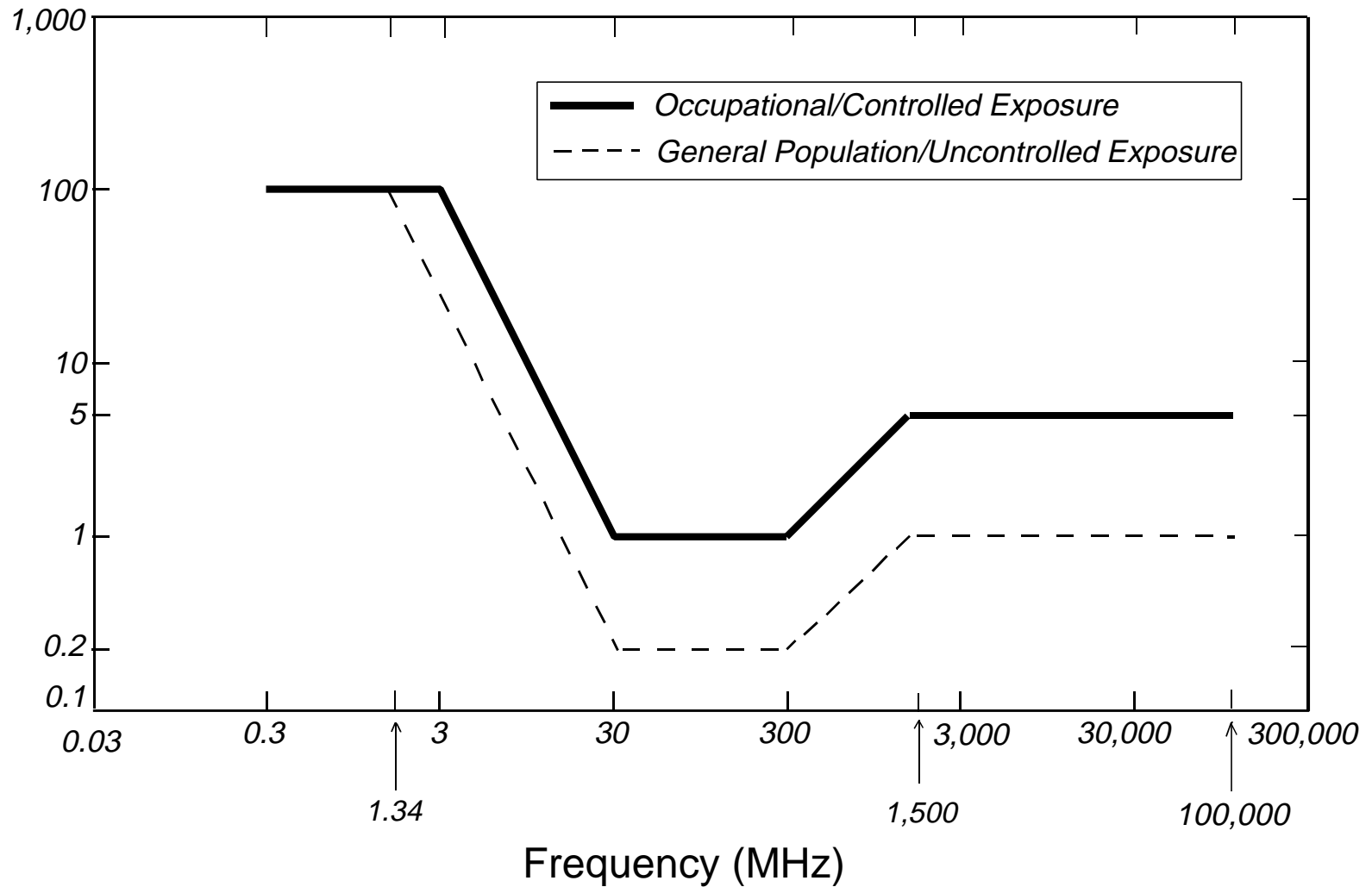


TABLE 2: TRANSMITTERS, FACILITIES AND OPERATIONS SUBJECT TO ROUTINE ENVIRONMENTAL EVALUATION

SERVICE (TITLE 47 CFR RULE PART)	EVALUATION REQUIRED IF:
Experimental Radio Services (part 5)	power > 100 W ERP (164 W EIRP)
Multipoint Distribution Service (subpart K of part 21)	<u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> power > 1640 W EIRP <u>building-mounted antennas</u> : power > 1640 W EIRP
Paging and Radiotelephone Service (subpart E of part 22)	<u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> power > 1000 W ERP (1640 W EIRP) <u>building-mounted antennas</u> : power > 1000 W ERP (1640 W EIRP)
Cellular Radiotelephone Service (subpart H of part 22)	<u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> total power of all channels > 1000 W ERP (1640 W EIRP) <u>building-mounted antennas</u> : total power of all channels > 1000 W ERP (1640 W EIRP)

TABLE 2 (cont.)

SERVICE (TITLE 47 CFR RULE PART)	EVALUATION REQUIRED IF:
Personal Communications Services (part 24)	<p>(1) Narrowband PCS (subpart D): <u>non-building-mounted antennas</u>: height above ground level to lowest point of antenna < 10 m <u>and</u> total power of all channels > 1000 W ERP (1640 W EIRP) <u>building-mounted antennas</u>: total power of all channels > 1000 W ERP (1640 W EIRP)</p> <p>(2) Broadband PCS (subpart E): <u>non-building-mounted antennas</u>: height above ground level to lowest point of antenna < 10 m <u>and</u> total power of all channels > 2000 W ERP (3280 W EIRP) <u>building-mounted antennas</u>: total power of all channels > 2000 W ERP (3280 W EIRP)</p>
Satellite Communications (part 25)	all included
General Wireless Communications Service (part 26)	total power of all channels > 1640 W EIRP
Wireless Communications Service (part 27)	total power of all channels > 1640 W EIRP
Radio Broadcast Services (part 73)	all included

TABLE 2 (cont.)

SERVICE (TITLE 47 CFR RULE PART)	EVALUATION REQUIRED IF:
Experimental, auxiliary, and special broadcast and other program distributional services (part 74)	subparts A, G, L: power > 100 W ERP subpart I: <u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> power > 1640 W EIRP <u>building-mounted antennas</u> : power > 1640 W EIRP
Stations in the Maritime Services (part 80)	ship earth stations only
Private Land Mobile Radio Services Paging Operations (part 90)	<u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> power > 1000 W ERP (1640 W EIRP) <u>building-mounted antennas</u> : power > 1000 W ERP (1640 W EIRP)
Private Land Mobile Radio Services Specialized Mobile Radio (part 90)	<u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> total power of all channels > 1000 W ERP (1640 W EIRP) <u>building-mounted antennas</u> : total power of all channels > 1000 W ERP (1640 W EIRP)

TABLE 2 (cont.)

SERVICE (TITLE 47 CFR RULE PART)	EVALUATION REQUIRED IF:
Amateur Radio Service (part 97)	transmitter output power > levels specified in § 97.13(c)(1) of this chapter (see Table 1 in text)
Local Multipoint Distribution Service (subpart L of part 101)	<u>non-building-mounted antennas</u> : height above ground level to lowest point of antenna < 10 m <u>and</u> power > 1640 W EIRP <u>building-mounted antennas</u> : power > 1640 W EIRP LMDS licensees are required to attach a label to subscriber transceiver antennas that: (1) provides adequate notice regarding potential radiofrequency safety hazards, <i>e.g.</i> , information regarding the safe minimum separation distance required between users and transceiver antennas; and (2) references the applicable FCC-adopted limits for radiofrequency exposure specified in § 1.1310 of this chapter.

Mobile and Portable Devices

Mobile and portable transmitting devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services (PCS), the Satellite Communications Services, the Maritime Services (ship earth stations only) and the Specialized Mobile Radio (SMR) Service are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use, as specified in 47 CFR § 2.1091 and § 2.1093. Unlicensed PCS and millimeter wave devices are also subject to routine environmental evaluation for RF exposure prior to equipment authorization or use, as specified in 47 C.F.R. § 15.253(f), § 15.255(g), and § 15.319(i). All other mobile, portable, and unlicensed transmitting devices are categorically excluded from routine environmental evaluation for RF exposure under 47 CFR § 2.1091 and § 2.1093, except (as described previously) as specified in 47 CFR § 1.1307(c) and (d) .

(a) Mobile Devices

This section describes the requirements of Section 2.1091 of the FCC's Rules (47 CFR § 2.1091) that apply to "mobile" devices. For purposes of these requirements mobile devices are defined as transmitters designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons. In this context, the term "fixed location" means that the device is physically secured at one location and is not able to be easily moved to another location. Transmitting devices designed to be used by consumers or workers that can be easily re-located, such as wireless devices associated with a personal computer, are considered to be mobile devices if they meet the 20 centimeter separation requirement.

Mobile devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services, the Satellite Communications Services, the General Wireless Communications Service, the Wireless Communications Service, the Maritime Services and the Specialized Mobile Radio Service authorized under the following parts and subparts of the FCC's Rules: subpart H of part 22, part 24, part 25, part 26, part 27, part 80 (ship earth station devices only) and part 90 (SMR devices only), are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if they operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or if they operate at frequencies above 1.5 GHz and their ERP is 3 watts or more. Unlicensed personal communications service devices, unlicensed millimeter wave devices and unlicensed NII devices authorized under FCC Rule parts 15.253, 15.255 and subparts D and E of part 15 are also subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if their ERP is 3 watts or more or if they meet the definition of a portable device as specified below, requiring evaluation under the provisions of 47 CFR §2.1093. All other mobile and unlicensed transmitting devices are categorically excluded from routine environmental evaluation for RF exposure prior to equipment authorization or use, except as specified in 47 CFR §§ 1.1307(c) and 1.1307(d), as discussed previously.

The limits to be used for evaluation of mobile and unlicensed devices (except portable unlicensed devices) are the MPE field strength and power density limits specified in Table 1 above (and in 47 CFR §1.1310). Applications for equipment authorization must contain a statement confirming compliance with these exposure limits as part of their application. Technical information showing the basis for this statement must be submitted to the Commission upon request.

All unlicensed personal communications service (PCS) devices shall be subject to the limits for general population/uncontrolled exposure. For purposes of analyzing mobile transmitting devices under the occupational/controlled criteria specified in Table 1, time-averaging provisions of the guidelines may be used in conjunction with typical maximum duty factors to determine maximum likely exposure levels. Time-averaging provisions may not be used in determining typical exposure levels for devices intended for use by consumers in general population/uncontrolled environments. However, "source-based" time-averaging based on an inherent property or duty-cycle of a device is allowed. An example of this is the determination of exposure from a device that uses digital technology such as a time-division multiple-access (TDMA) scheme for transmission of a signal. In general, maximum average rms power levels should be used to determine compliance.

If appropriate, compliance with exposure guidelines for mobile and unlicensed devices can be accomplished by the use of warning labels and by providing users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.

In some cases, for example, modular or desktop transmitters, the potential conditions of use of a device may not allow easy classification of that device as either mobile or portable. In such cases, applicants are responsible for determining minimum distances for compliance for the intended use and installation of the device based on evaluation of either specific absorption rate (SAR), field strength or power density, whichever is most appropriate.

(b) Portable Devices

This section describes the requirements of Section 2.1093 of the FCC's Rules (47 CFR §2.1093) that apply to "portable" devices. For purposes of these requirements a portable device is defined as a transmitting device designed to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user.

Portable devices that operate in the Cellular Radiotelephone Service, the Personal Communications Services, the Satellite Communications Services, the General Wireless Communications Service, the Wireless Communications Service, the Maritime Services and the Specialized Mobile Radio Service, and authorized under the following sections of the FCC's rules: subpart H of part 22, part 24, part 25, part 26, part 27, part 80 (ship earth

station devices only), part 90 (SMR devices only), and portable unlicensed personal communication service, unlicensed NII devices and millimeter wave devices authorized under rule parts 47 CFR §§15.253, 15.255 or subparts D and E of part 15, are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use. All other portable transmitting devices are categorically excluded from routine environmental evaluation for RF exposure prior to equipment authorization or use, except as specified in 47 CFR §§ 1.1307(c) and (d), as discussed previously. Applications for equipment authorization of portable transmitting devices subject to routine environmental evaluation must contain a statement or certification confirming compliance with the limits specified below as part of their application. Technical information showing the basis for this statement must be submitted to the Commission upon request.

The limits to be used for evaluation are based generally on criteria published by the Institute of Electrical and Electronics Engineers, Inc., (IEEE) for localized specific absorption rate ("SAR") in Section 4.2 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992, Copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, Section 17.4.5. Copyright NCRP, 1986, Bethesda, Maryland 20814. SAR is a measure of the rate of energy absorption per unit mass due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potentially adverse biological effects. The criteria to be used are specified below and shall apply for portable devices transmitting in the frequency range from 100 kHz to 6 GHz. Portable devices, as defined above, that transmit at frequencies above 6 GHz are to be evaluated in terms of the MPE limits specified in Table 1 above (and in 47 CFR §1.1310). Measurements and calculations to demonstrate compliance with MPE field strength or power density limits for devices operating above 6 GHz should be made at a minimum distance of 5 cm from the radiating source.

(1) Limits for Occupational/Controlled exposure: 0.4 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 8 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 20 W/kg, as averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Occupational/Controlled limits apply when persons are exposed as a consequence of their employment provided these persons are fully aware of and exercise control over their exposure. Awareness of exposure can be accomplished by use of warning labels or by specific training or education through appropriate means, such as an RF safety program in a work environment.

(2) Limits for General Population/Uncontrolled exposure: 0.08 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 1.6 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 4 W/kg, as averaged over

any 10 grams of tissue (defined as a tissue volume in the shape of a cube). General Population/Uncontrolled limits apply when the general public may be exposed, or when persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or do not exercise control over their exposure. Warning labels placed on consumer devices such as cellular telephones will not be sufficient reason to allow these devices to be evaluated subject to limits for occupational/controlled exposure.

Compliance with SAR limits can be demonstrated by laboratory measurement techniques or by computational modeling, as appropriate. Methodologies and references for SAR evaluation are described in technical publications including "IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave," IEEE C95.3-1991, and further guidance on measurement and computational protocols is being developed by the IEEE and others (see text of this bulletin for further discussion).

For purposes of analyzing a portable transmitting device under the occupational/controlled criteria only, the time-averaging provisions of the MPE guidelines identified in Table 1 above can be used in conjunction with typical maximum duty factors to determine maximum likely exposure levels. However, assurance must be given that use of the device will be limited to occupational or controlled situations, as defined previously.

Time-averaging provisions of the MPE guidelines identified in Table 1 may not be used in determining typical exposure levels for portable devices intended for use by consumers, such as hand-held cellular telephones, that are considered to operate in general population/uncontrolled environments as defined above. However, "source-based" time-averaging based on an inherent property or duty-cycle of a device is allowed. An example of this would be the determination of exposure from a device that uses digital technology such as a time-division multiple-access (TDMA) scheme for transmission of a signal. In general, maximum average rms power levels should be used to determine compliance.

APPENDIX B

Summary of 1986 Mass Media Bureau Public Notice on RF Compliance

On January 28, 1986, the FCC's Mass Media Bureau released a Public Notice providing guidance to broadcast licensees and applicants regarding compliance with the FCC's RF exposure guidelines.³⁸ The primary sections of that Public Notice are reproduced below (text in brackets has been added or edited). Non-broadcast applicants and licensees may also find this information helpful in evaluating compliance (see discussion in text of Section 4 on controlling exposure).

"Most broadcasting facilities produce high RF radiation levels at one or more locations near their antennas. That, in itself, does not mean that the facilities significantly affect the quality of the human environment. Each situation must be examined separately to decide whether humans are or could be exposed to high RF radiation.
[A]ccessibility is a key factor in making such a determination. As a general principle, if areas of high RF radiation levels are publicly marked and if access to such areas is impeded or highly improbable (remoteness and natural barriers may be pertinent) then it may be presumed that the facilities producing the RF radiation do not significantly affect the quality of the human environment and do not require the filing of an [E]nvironmental [A]ssessment. Because we wish to avoid burdening applicants with unnecessary work, expenses and administrative filings, we offer the following guidance as to how we will view typical situations. The term "high RF level" means an intensity of RF radiation, whether from single or multiple sources, which exceeds the [FCC] guidelines.

Situations

(A) High RF levels are produced at one or more locations above ground level on an applicant's tower.

- If the tower is marked by appropriate warning signs, the applicant may assume that there is no significant effect on the human environment with regard to exposure of the general public.

(B) High RF levels are produced at ground level in a remote area not likely to be visited by the public.

³⁸ *Further Guidance for Broadcasters Regarding Radiofrequency Radiation and the Environment*, January 28, 1986, FCC Public Notice No. 2278.

- If the area of concern is marked by appropriate warning signs, an applicant may assume that there is no significant effect on the human environment with regard to exposure of the general public. It is recommended that fences also be used where feasible.

(C) High RF levels are produced at ground level in an area which could reasonably be expected to be used by the public (including trespassers).

- If the area of concern is fenced and marked by appropriate warning signs, an applicant can assume that there is no significant effect on the human environment with regard to exposure of the general public.

(D) High RF levels are produced at ground level in an area which is used or is likely to be used by people and to which the applicant cannot or does not restrict access.

- The applicant must submit an [E]nvironmental [A]ssessment [*unless corrective action is taken prior to submission of an application*]. This situation may require a modification of the facilities to reduce exposure or could lead to a denial of the application.

(E) High RF levels are produced in occupied structures, on balconies, or on rooftops used for recreational or commercial purposes.

- The applicant must submit an [E]nvironmental [A]ssessment [*unless corrective action is taken prior to submission of an application*]. The circumstances may require a modification of the broadcasting facility to reduce exposure or could lead to a denial of the application.

(F) High RF levels are produced in offices, studios, workshops, parking lots or other areas used regularly by station employees.

- The applicant must submit an [E]nvironmental [A]ssessment [*unless corrective action is taken prior to submission of an application*]. The circumstances may require a modification of the facilities to reduce exposure or the application may be denied. This situation is essentially the same as (E). We have included it to emphasize the point that station employees as well as the general public must be protected from high RF levels [*also, see FCC definitions used to determine application of exposure tiers: general population/uncontrolled vs. occupational/controlled*]. Legal releases signed by employees willing to accept high exposure levels are not acceptable and may not be used in lieu of corrective measures.

(G) High RF levels are produced in areas where intermittent maintenance and repair work must be performed by station employees or others.

- [FCC] guidelines also apply to workers engaged in maintenance and repair. As long as these workers will be protected from exposure to levels exceeding [FCC] guidelines, no [E]nvironmental [A]ssessment is needed. Unless requested by the Commission, information about the manner in which such activities are protected need not be filed. If protection is not to be provided, the applicant must submit an [E]nvironmental [A]ssessment. The circumstances may require corrective action to reduce exposure or the application may be denied. Legal releases signed by workers willing to accept high exposure levels are not acceptable and may not be used in lieu of corrective measures.

The foregoing also applies to high RF levels created in whole or in part by reradiation.

A convenient rule to apply to all situations involving RF radiation is the following:

(1) Do not create high RF levels where people are or could reasonably be expected to be present, and (2) [p]revent people from entering areas in which high RF levels are necessarily present.

Fencing and warning signs may be sufficient in many cases to protect the general public. Unusual circumstances, the presence of multiple sources of radiation, and operational needs will require more elaborate measures.

Intermittent reductions in power, increased antenna heights, modified antenna radiation patterns, site changes, or some combination of these may be necessary, depending on the particular situation.

EXHIBIT M:

FCC ET DOCKET NO. 03-137
COMMENTS FROM RICHARD A. TELL

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
)	
Reassessment of Federal Communications)	ET Docket No. 13-84
Commission Radiofrequency Exposure Limits and)	
Policies)	
)	
Proposed Changes in the Commission's Rules)	ET Docket No. 03-137
Regarding Human Exposure to Radiofrequency)	
Electromagnetic Fields)	
)	

COMMENTS OF RICHARD A. TELL
Submitted August 27, 2013

Richard A. Tell, President of the firm of Richard Tell Associates, Inc. submits these Comments in response to the publication of FCC 13-39, First Report and Order, Further Notice of Proposed Rule Making and Notice of Inquiry (ET Docket No. 13-84 and ET Docket No. 03-137) released March 29, 2013 by the FCC. Richard Tell has 46 years of experience directly related to matters of radiofrequency (RF) safety, with 20 of those years in service to the U.S. Environmental Protection Agency (EPA) and the last 26 years in private consulting practice of RF hazard identification, assessment and resolution. He has been a participant in the Institute of Electrical and Electronic Engineers (IEEE) since the late 1960's and serves as Chairman of Subcommittee 2 (Subcommittee on Terminology, Units of Measurement, and Hazard Communications) of the IEEE's International Committee on Electromagnetic Safety (ICES). He is also Chairman of the IEEE Committee on Man and Radiation (COMAR). Mr. Tell has provided RF safety support over the years to various large scale broadcast sites including the former World Trade Center, the Empire State Building, 4Times Square, Hancock Center, Tucson Mountain and high power international broadcast sites, etc., as well as to wireless telecommunications operators throughout the United States. Mr. Tell holds a B.S. degree in physics and an M.S. degree in radiation sciences. He is a Life Fellow of the IEEE. His experience and background are known to the Commission through several contracts to the Office of Engineering and Technology on RF safety related projects. These comments are those of Richard A. Tell, personally, and not as a representative of the IEEE or any of its committees.

These comments are presented in the order of the various paragraphs of the subject documents with the paragraph number at the beginning of each comment.

25: The statement that "...where the compliance of a devise or transmitter installation is based on MPE assessment and is later found to be noncompliant with the MPE requirement, *post factum* SAR evaluation showing compliance with the SAR guidelines will not be allowed as a response to enforcement action." is inconsistent with the fundamental basis of using SAR as the basic restriction underlying the MPE rules and should be deleted. Both the ICNIRP guidelines and the IEEE standard state the following:

ICNIRP

Purpose and Scope: "In any particular exposure situation, measured or calculated values of any of these quantities can be compared with the appropriate reference level. Compliance with the reference level will

ensure compliance with the relevant basic restriction. If the measured or calculated value exceeds the reference level, it does not necessarily follow that the basic restriction will be exceeded.”

IEEE

Clause 3.1.39: “If an exposure is proven to be below the basic restrictions, the MPE can be exceeded. MPEs are sometimes called *reference levels, derived limits, or investigation levels.*”

Clause 4.4: “If the BRs given above are not exceeded, the MPEs in Table 8 and Table 9 can be exceeded.”

Clause 4.7: “In cases where the measured exposure parameters approach or exceed the MPE, the more complex evaluation of SAR may be used to make a further determination of compliance with the standard.”

Should a transmitter site be subsequently found to exhibit RF fields in excess of the MPE, it is only reasonable that the relevant “non-compliant” party be permitted to conduct whatever kind of evaluation they deem technically appropriate, including an assessment of SAR, to further assess compliance at the site. If this were not allowed, then sites that are actually in compliance could be deemed non-compliant with subsequent inappropriate penalties. Any party designated as “non-compliant” should always be permitted the opportunity to use the more involved, complex and expensive approach of using SAR in the assessment of compliance.

183: The FCC proposes to allow transient exposures of the general public where the general population limit is exceeded (but not the occupational limit) so long as adequate controls are in place and the 30-minute averaging time is used and the person is escorted by a person qualified to be in the controlled environment. There is no reason why the peak exposure shouldn’t be allowed to exceed the occupational limit so long as the time averaged value does not exceed the public MPE. If the presence of the transient individual is to be supervised to insure that the time-averaged public MPE is not exceeded, then there is no logical reason that the same person should not be qualified to insure that the time-averaged exposure is in compliance regardless of the momentary magnitude of the exposure level.

195: A detailed definition of the term “training” is needed. For example, training could simply include RF safety information provided in the form of an informational sheet...not formal classroom training. In most instances, based on personal experience, formalized classroom type training often misses the purpose of insuring that workers know what to do and what not to do at an active antenna site. In most cases, very limited but specific instruction on behavior at an active antenna site is entirely sufficient to achieve compliance with the RF exposure limits adopted by the FCC. The abbreviated approach to “training” described here is also highly cost effective, resulting in much lower cost to antenna or site operators.

196. For Category Two – NOTICE (Exceeds General Population Exposure Limit but Less Than the Occupational Exposure Limit), the text is not clear. This section begins by stating that signs and positive access control is proposed to be required surrounding areas in which the general population exposure limit is exceeded. However, it then proposes that under certain “controlled” conditions, positive access control is apparently not required if a label or small sign is affixed to the surface of an antenna that specifies a minimum approach distance with the assumption that the label can be read from the required separation distance. An example is provided of a “controlled” condition as being a rooftop with limited access such as a locked door with appropriate signage. Physically restricting access to an area to those authorized to enter the site does not necessarily imply that those that are authorized to enter the site are fully aware of the potential to be exposed above the general public MPE. Hence, in general, most persons entering such a site are classified as members of the general public and subject to the lower tier of exposure limits. Examples include electricians, telephone repair personnel, roof repair workers, window washing crews, pest control

technicians, etc. If the assumption is made that all individuals on the site can read the applicable label on an antenna and will abide by the indicated exclusion distance, without positive access control to the area in which the RF fields exceed the public limit, then it should follow that signage is sufficient at any transmitter site, without a requirement for positive access control.

It should be noted that the IEEE lower tier (in IEEE Std. C95.1-2005) is an “action level” to do something; it is not reflective of a biological limit, per se! Hence, there is no need for FCC to treat it as a legal exposure limit. It is, however, a level above which the FCC should require action to be taken to insure that exposure of individuals does not exceed the upper tier. Through such a requirement, an RF safety program would be instituted whereby any individuals within the area affected by the program would, through their awareness of the possibility of exposure, and consistent with other requirements of the FCC, would be subject to the occupational exposure limits. In fact, necessarily, and importantly, there is NO biological difference between individuals in the general population and those in occupational positions in regard to any underlying differential sensitivity to RF exposure. The only distinction between the two classes of individuals is awareness of potential exposure exceeding the lower tier of limits.

196 bottom: This section needs to be more precisely explained. Specifically, under what condition is lockout/tagout required if exposure exceeds ten times the occupational limit? Is a ten-fold value in terms of the momentary peak value or time averaged value of field?

212: The specification that the MPE limits apply to the environmental level of RF field strength without the body present is an excellent point. Body interaction with the field being measured can result in significant errors relative to assessing compliance and can go both ways; in some cases the presence of the observer can lead to erroneously high values of fields while in other instances, lower values of fields. When reporting measurements for compliance purposes, it is recommended that data illustrating the effect of the observer making the measurements be provided as part of the overall evaluation.

221. The text addressing “averaging area” is also discussed at the bottom of page 197 where it is stated that at locations close to antennas where spatial averaging may not be appropriate (because the localized SAR limit may be exceeded), “the spatial peak field should be used to determine compliance”. This requirement will have impact on compliance evaluations in that the region around transmit antennas that will be determined to be noncompliant with the FCC limits will, generally, increase. It is important to note that in general, there is no convenient way to know when the local RF field may cause local SAR to exceed the SAR limit. This will, hence, lead to the use of the more conservative application of the spatial peak field in lieu of the spatially averaged field for compliance determinations. The FCC should consider providing guidance on what values of local RF fields can result in exceeding of the local SAR limit. With greater areas surrounding transmitting antennas that may result in exceeding the local SAR limit, more extensive barriers will be required at an additional expense. In many cases, these more expansive barriers will not be necessary.

223: In the case of smart meters, the transmit activity of any given meter typically varies over time but is always a small percentage. In several studies related to smart meters, duty cycles have been examined from two different perspectives, direct measurement and statistical evaluation based on interrogation of the meter management software used by electric utilities. In both cases, the maximum duty cycles have been found to range upward to a few percent for a very small number of meters with much lower values for the vast majority of meters.

Figure 1 provides the results of a study of smart meter duty cycles where the sample interval varied from 1 to 126 minutes (just over two hours) for a sample of 88,296 smart meters deployed by Pacific Gas and Electric

(PG&E). The figure shows the maximum, minimum, average and standard deviation of the duty cycles. The results show that the average duty cycle is relatively small, typically being less than 0.1%. During short momentary periods, the maximum duty cycle can range up to slightly greater than 10%.

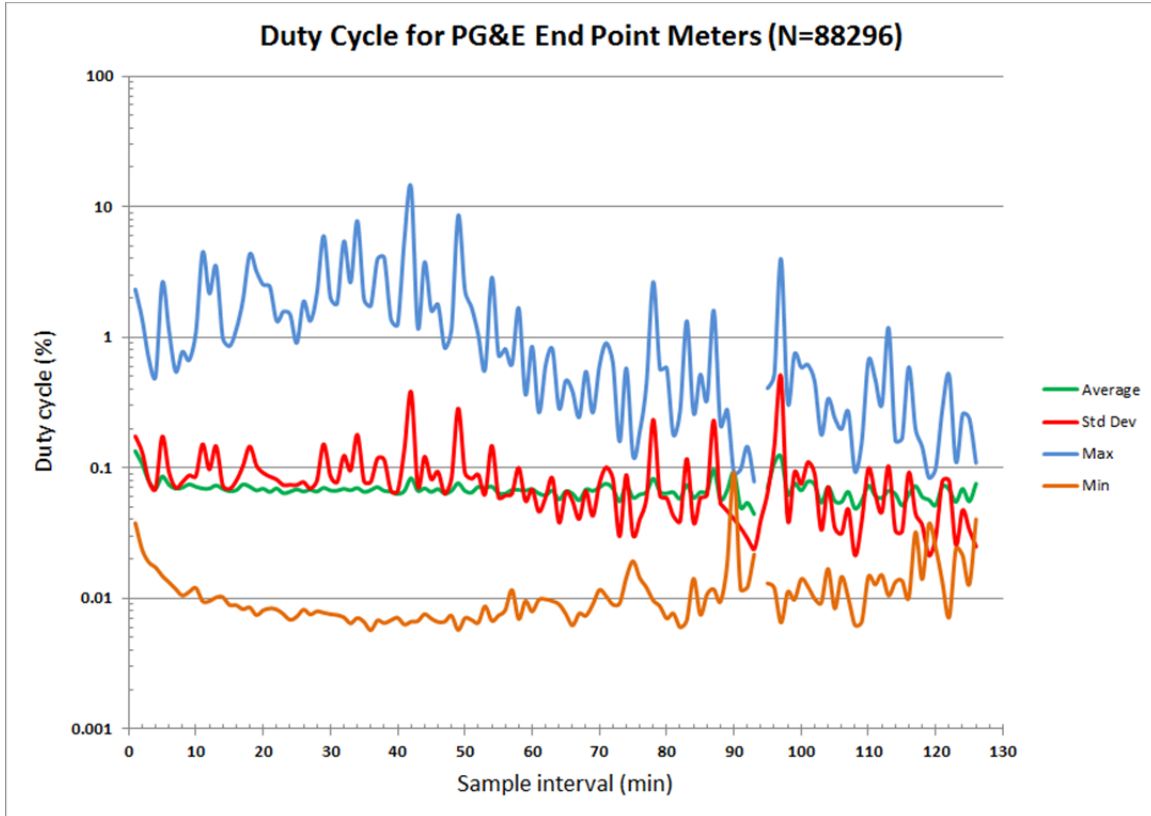


Figure 1. Duty cycle based on a study of 88,296 Pacific Gas and Electric Company (PG&E) end point smart meters in which a range of sample intervals (averaging times) was used ranging from 1 to 126 min. Figure 5 from Tell, R.A., R. Kavet and G. Mezei (2012). Characterization of radiofrequency field emissions from smart meters. *Journal of Exposure Science and Environmental Epidemiology* (2012), 1-5.

These data can be viewed differently in Figure 2 where the cumulative percentile of smart meter exhibiting various duty cycles over the sampling periods of 1 to 126 minutes is displayed.

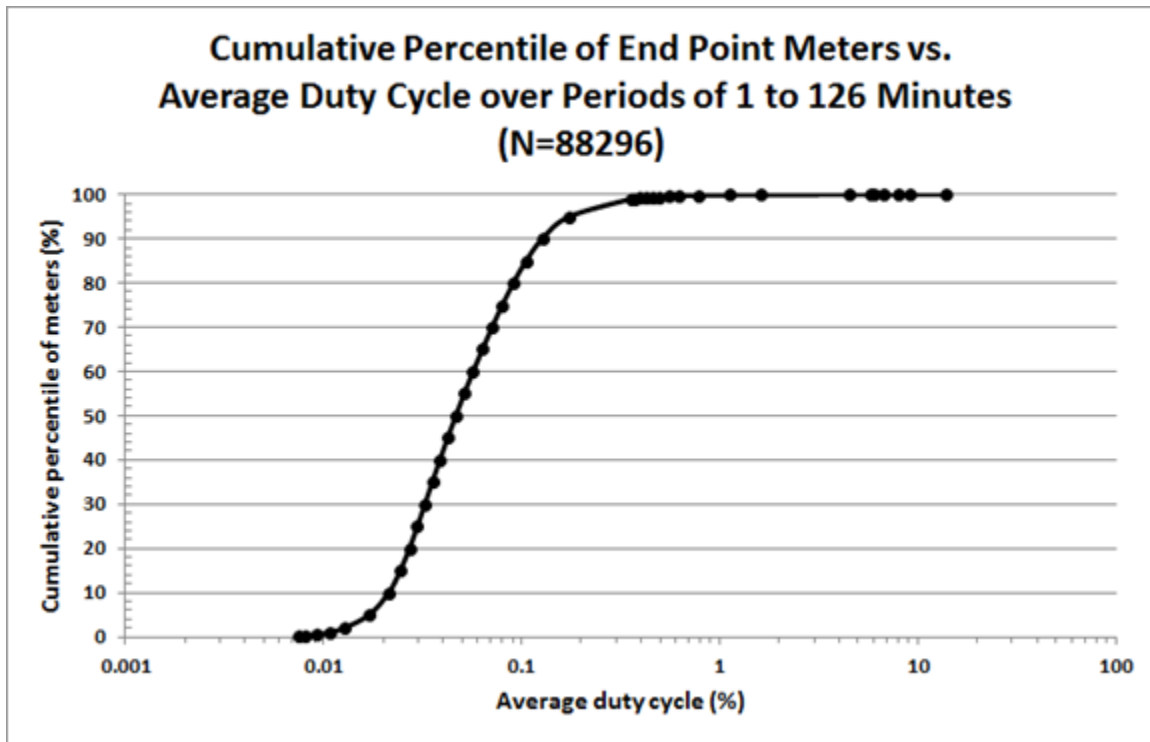


Figure 2. Percentile analysis of duty cycles from 88,296 end point smart meters with sampling periods from 1 to 126 min. Figure 6 from Tell, R.A., R. Kavet and G. Mezei (2012). Characterization of radiofrequency field emissions from smart meters. *Journal of Exposure Science and Environmental Epidemiology* (2012), 1-5.

The data demonstrate that for all meters combined, regardless of the sampling interval, half exhibited duty cycles <0.0465%; 99% had duty cycles of no more than 0.355%; 99.9% had duty cycles <1.12%; and 99.99% of meters had duty cycles <4.54%.

In another study of smart meter duty cycles deployed by Southern California Edison (SCE), with a sample size of 47,000 meters monitored over an 89 day period, similarly small values were found (see Figure 3). In this study, end point smart meters as well as those meters that act as data collectors (in this case referred to as cell relays) were studied. The maximum duty cycle for the SCE RF LAN transmitters was 4.74%, which occurred in the highest 1/10th percentile of values, dropping to a 99th percentile duty cycle of only 0.11%. From the 10th to 99th percentile, the duty cycles ranged from ~0.001 to 0.1%.

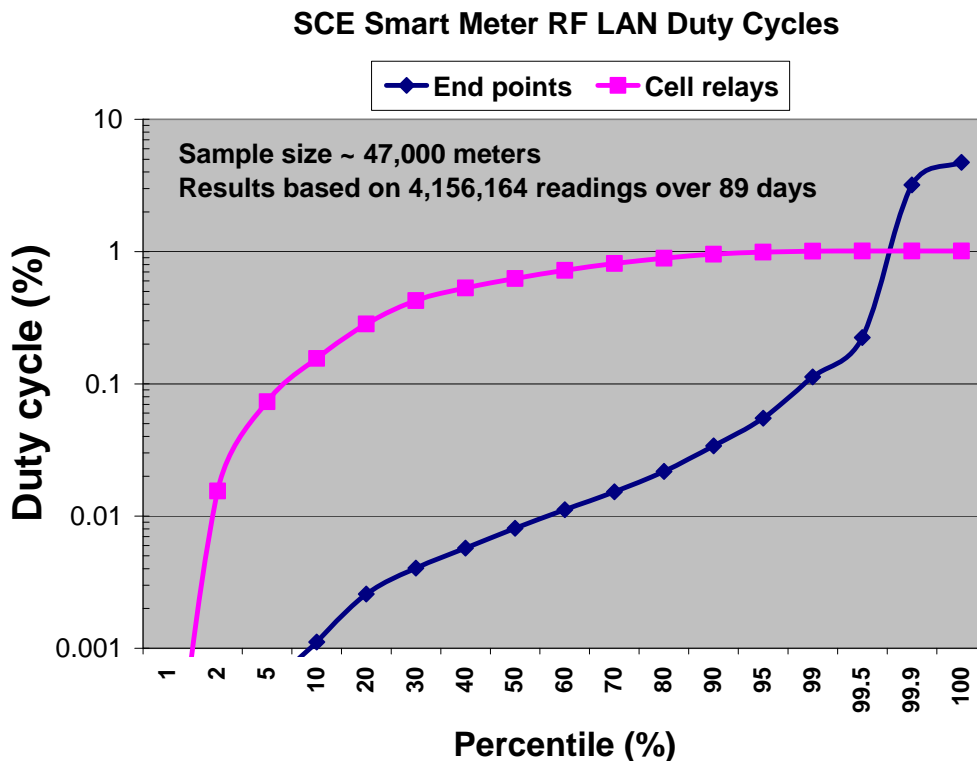


Figure 3. Analysis of Southern California Edison (SCE) daily average RF LAN duty cycle distribution for different percentiles based on 4,156,164 readings of transmitter activity from an average of 46,696 Itron smart meters over a period of 89 consecutive days. Analysis based on estimated transmitter activity during a day. Figure 13 from Tell, R.A., G.G. Sias, A. Vazquez, J. Sahl, J.P. Turman, R. I. Kavet and G. Mezei (2012). Radiofrequency fields associated with the Itron smart meter. *Radiation Protection Dosimetry Advance Access* published January 10, 2012, pp. 1-13.

Yet another study of smart meters used by San Diego Gas and Electric (SDG&E) was based on an assessment of 6,865 meters observed over a one day period. In the SDG&E sample, the smart meters with the highest activity had lower duty cycles than the SCE smart meters with the highest activity, but overall the duty cycles were in equivalent ranges. Figure 4 shows the results. For instance, half of the SDG&E meters exhibited duty cycles of 0.06% or more. The 50th percentile of duty cycles in the SCE data was 0.01% for SCE; SDG&E's 95th percentile value was 0.08% compared with SCE's 0.06%.

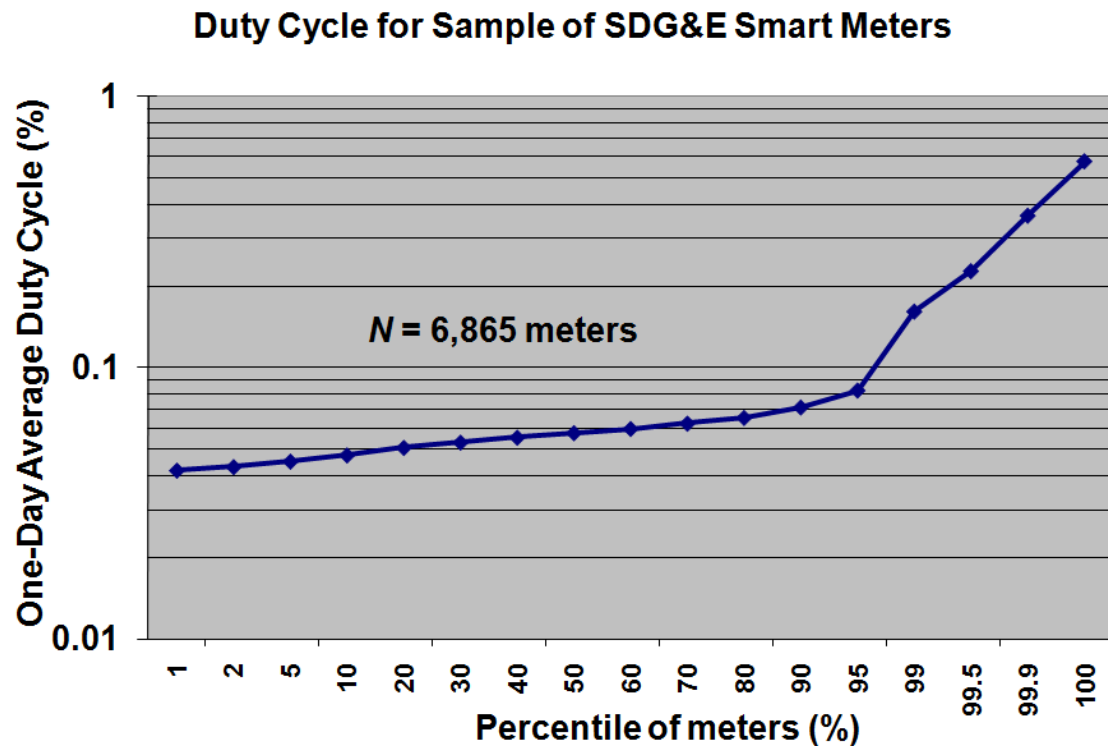


Figure 4. Results of an analysis of duty cycles for a sample of 6865 Itron smart meters deployed by San Diego Gas and Electric (SDG&E) based on transmit duration during a single day of observation. Figure 14 from Tell, R.A., G.G. Sias, A. Vazquez, J. Sahl, J.P. Turman, R. I. Kavet and G. Mezei (2012). Radiofrequency fields associated with the Itron smart meter. *Radiation Protection Dosimetry Advance Access* published January 10, 2012, pp. 1-13.

A study of smart meter emissions in the state of Vermont included direct measurements of meter emission duty cycle from a single meter that had been strategically selected because of its hierarchical location within the smart meter wireless mesh network. The meter in question relayed data from 554 other end point meters within the network. Measurements of the RF emissions were made over a 30-minute period timed to coincide with the reporting time for the meter. The maximum duty cycle observed was 3.55%. Figure 5 illustrates the result of the measurement over a 30-minute window.

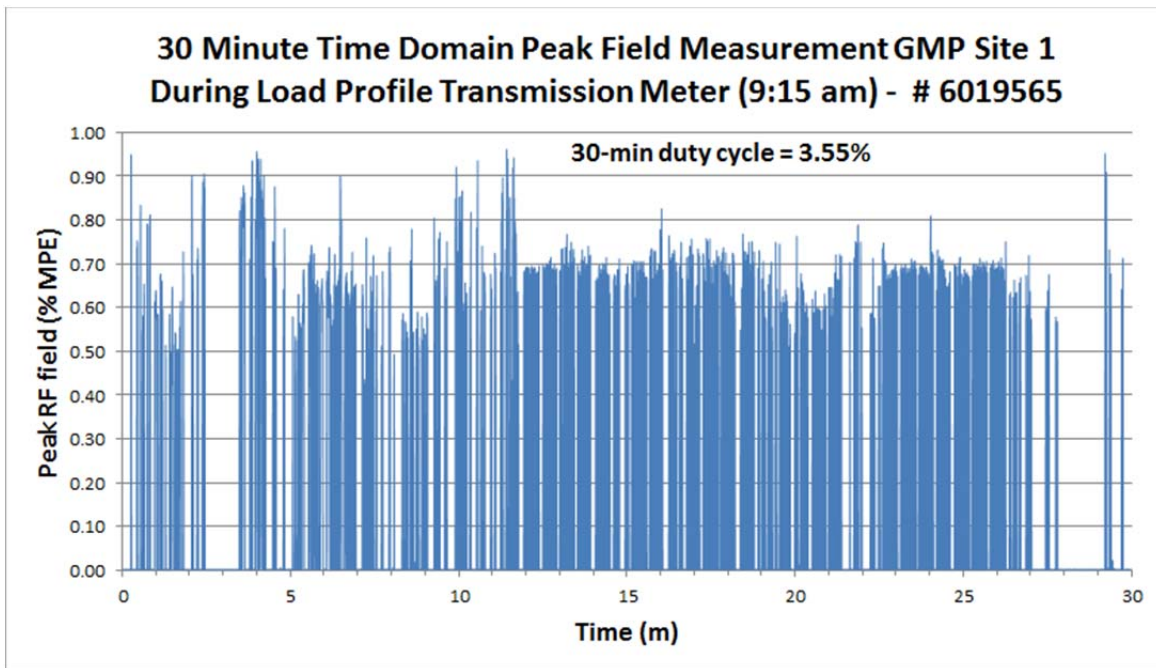


Figure 5. Result of 30-minute time domain measurement of peak RF fields at Green Mountain Power site 1 during period of maximum expected transmit activity. The 30-minute duty cycle was measured to be 3.55% during this period of maximum transmitter activity when the meter was relaying data from 554 other end point meters. Figure 31 from technical report: An Evaluation of Radio Frequency Fields Produced by Smart Meters Deployed in Vermont. Prepared for the Vermont Department of Public Service by R.A. and C.A. Tell, Richard Tell Associates, Inc., January 14, 2013, 137 p.

224: Presently available data on biological effects indicates that the average value of the plane wave equivalent power density is the exposure parameter most closely related to potential adverse biological effects. It would be outside the framework of current mainstream science for the FCC to adopt limits on the peak value of pulsed RF fields.

225: It is true that higher frequencies do not result in greater induced currents, and associated voltages, in long conductive structures. Figure 6, illustrates the magnitude of contact current that would be expected when an individual would touch a vertical conductor immersed in RF electric fields of 1, 10 and 100 MHz. The figure shows that as frequency is increased, the length of the conductor that results in a maximum contact current is shorter; for a given frequency, there is a maximum length beyond which greater contact current does not occur. Because sufficiently great RF currents can lead to burns on the skin, the FCC should include limits on contact currents, something that it has not done since its Report and Order issued in 1996 in ET Docket 93-62. Instrumentation has been available for many years and is routinely used for measurements of compliance with the IEEE standard. Besides the direct hazard of tissue burning from contact currents, the FCC should also include a limit on open circuit RF voltage, as included in IEEE Standard C95.1-2005, to eliminate the hazard of arcing between a person and RF energized objects. Please see response to paragraph 227.

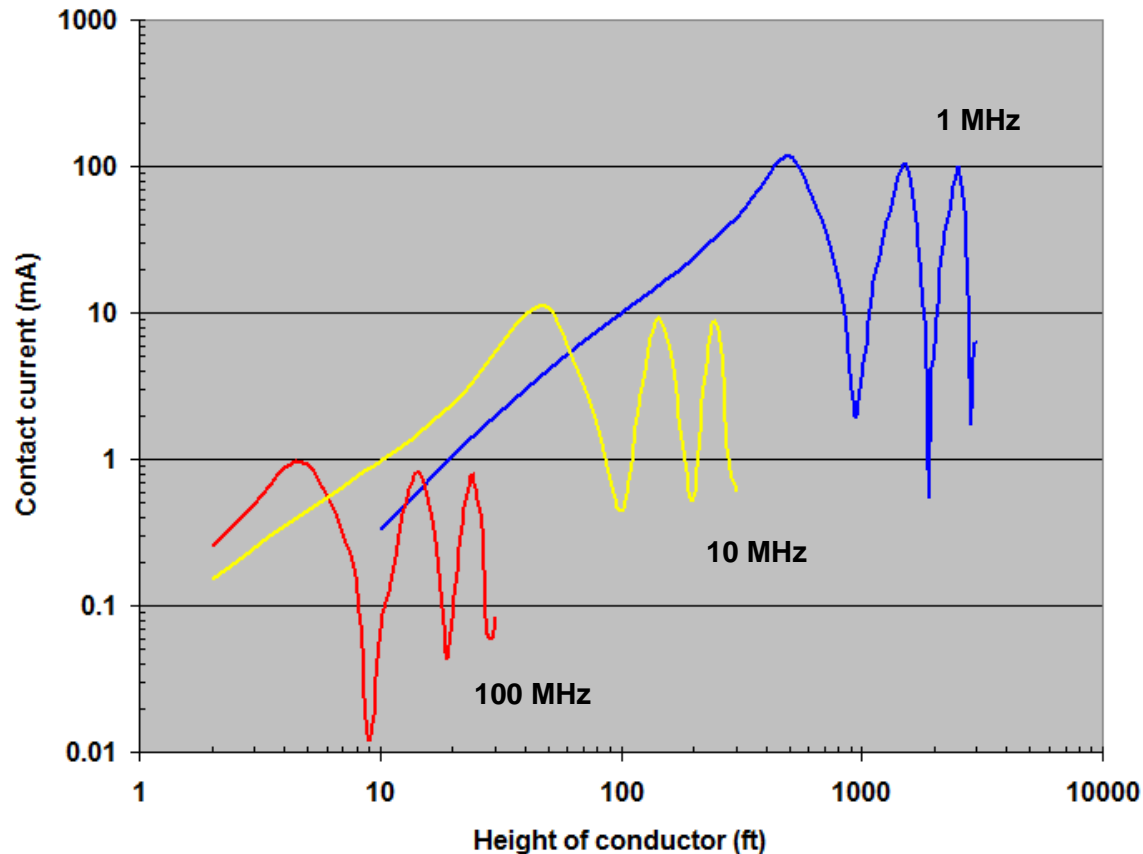


Figure 6. Calculated contact current vs. height of conductor exposed to an electric field strength of 1 V/m for frequencies of 1, 10, and 100 MHz. Note the similar behavior of the oscillation in contact currents but, importantly, the diminished value of the peak currents at higher frequencies. Adapted from Figure 6 from Olsen, R.G., J. Schneider and R. A. Tell (2011). Radiofrequency burns in the power system workplace. *IEEE Transactions on Power Delivery*, Vol. 26, Issue 1, pp. 352-359.

226: RF fields of even modest magnitudes can energize conductive structures such as guy wires, electric power transmission poles, electrical cables, tall cranes and house wiring such that these structures can become potent sources of contact current and/or open circuit RF voltage. This phenomenon is largely, but not completely, related to AM radio broadcasting antennas. Because contact with such structures can lead to excessive contact current and RF burns, it would be beneficial for the FCC to provide publicly available maps showing areas where electric fields produced by AM broadcast stations exceed a specific criterion. This approach has been accomplished in a project sponsored by the Electric Power Research Institute (EPRI) in the form of a software tool that combines mapping of AM broadcast stations in the U.S. and Canada with radiation pattern data that illustrates regions in which RF fields have the potential of exceeding an electric field strength of 2 V/m, this value being deemed sufficient to result in high open circuit voltages on large conductive structures sufficient to result in arcing to ground. See EPRI Technical Brief: Use of a Geographic Mapping Tool in Power Line Routing for RF Hazard Identification: A Feasibility Evaluation. EPRI product ID 1023107, November 16, 2011. Prepared for EPRI by Richard Tell Associates, Inc. Figure 7 provides an illustration of how such mapping can be prepared.



Figure 7. Illustration of a mapping of electric field strengths of 2 V/m in the vicinity of AM radio broadcast stations in a portion of the Atlanta, GA area. Non-circular icons are used in the case of directional stations showing the 2 V/m contour. This example was used to illustrate the extent of RF fields in the region of an electric power substation that was located immediately adjacent to several AM radio stations (note the yellow dot that represents the area in which RF fields are projected to exceed 2 V/m that covers the area of the substation).

227. In a practical sense, the only real hazard of RF exposure is the production of RF burns. This is particularly true when considering RF fields with magnitudes in the range of the present FCC MPE values. Because ambient RF fields that are a small fraction of the FCC MPE can lead to open circuit voltages that can easily arc to a person attempting contact with an energized object, the RF burn hazard is commonly ignored during typical RF field compliance evaluations. Figure 8 provides measurement data showing the relationship between incident RF electric field strength and the open circuit voltage measured at the bottom end of two different crane cables. These data show that for the conditions under which the measurements were made, an incident electric field equivalent to the FCC MPE across the AM radio broadcast band of 614 V/m for occupational exposure and for frequencies up to 1340 kHz for general population/uncontrolled

exposure could result in an open circuit voltage of approximately 56 kV. Voltages of this magnitude will result in substantial arcing. Because of this, it is especially relevant that the FCC take steps to eliminate the most hazardous effect of RF exposure.

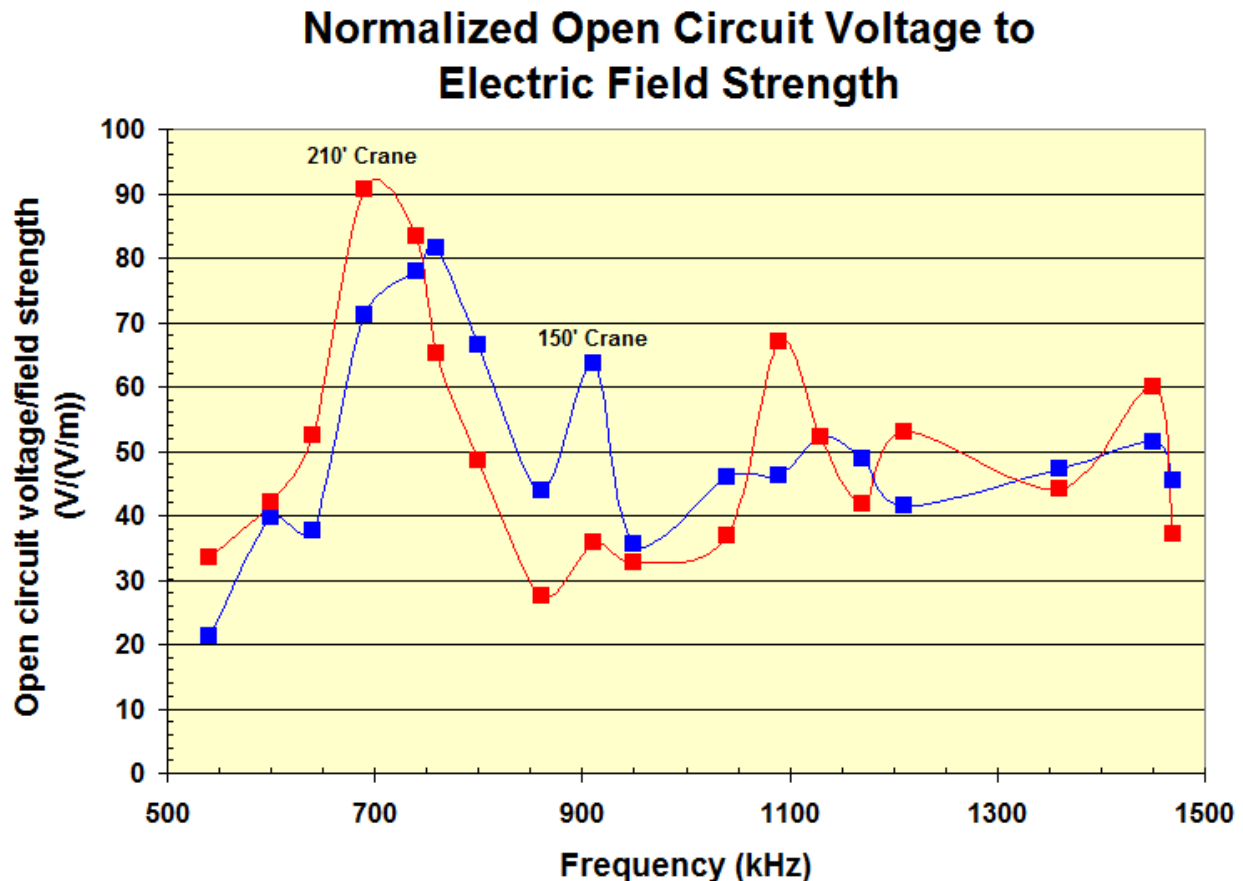


Figure 8. Ratio of measured open circuit RF voltage to measured electric field strength as a function of frequency across the AM radio broadcast band for two different cranes (cranes were not aligned relative to the various AM radio stations in the same way).

This can be accomplished by adopting limits on open circuit voltages and contact currents. When this issue arises, the determination of responsibility should be driven by whether the station or affected party was first present at the site. If the affected party is the result of development activities near an existing AM station, responsibility should fall on the affected party. Alternatively, if a station establishes operation within an area with existing development, the responsibility should fall to the station.

228: Because RF burns are the only known and demonstrated hazard related to RF exposure that are associated with field strengths equivalent to the present FCC MPEs, the FCC should certainly address this deficiency in the present rules by adopting relevant limits for contact currents and open circuit voltages. While it is true that interactions between RF fields and various structures in the environment can be complicated, such complexity associated with the relevant hazard evaluation should not be used as a rationale for continuing to ignore the potential seriousness of the RF burn hazard. The FCC should adopt relevant numerical values for both contact currents and open circuit voltages that can lead to arcing, perhaps the most hazardous of all RF exposure scenarios. Instrumentation has existed for years that allows for

quantifying these exposure parameters. Any additional burden associated with the inclusion of such limits in compliance evaluations is clearly offset by the benefit of RF burn hazard reduction.

240: The suggestion by some of applying extremely stringent, precautionary limits would have the severe consequence of impacting broadcasting and telecommunications as they are currently known and appreciated in the U.S. For example, a recent proposal to apply an RF power density limit of 0.3 nW/cm^2 is, simply, not practical. This conclusion is exemplified by Figure 9, in which population exposure to VHF and UHF broadcast fields was estimated from detailed measurements in 15 metropolitan areas of the U.S. The data show that virtually the entire population of the cities studied was exposed to RF fields exceeding the recommended, precautionary limit of 0.3 nW/cm^2 . While the data are from the 1978-1980 era, no follow-up work of this magnitude has been accomplished since and it is anticipated that since the time of this study, the introduction of wireless communications (cellular telephone) base stations has likely not reduced population exposure levels. Hence, the implementation of precautionary exposure measures similar to this would certainly impact on the ability to provide domestic broadcasting service and wireless communications as currently available.

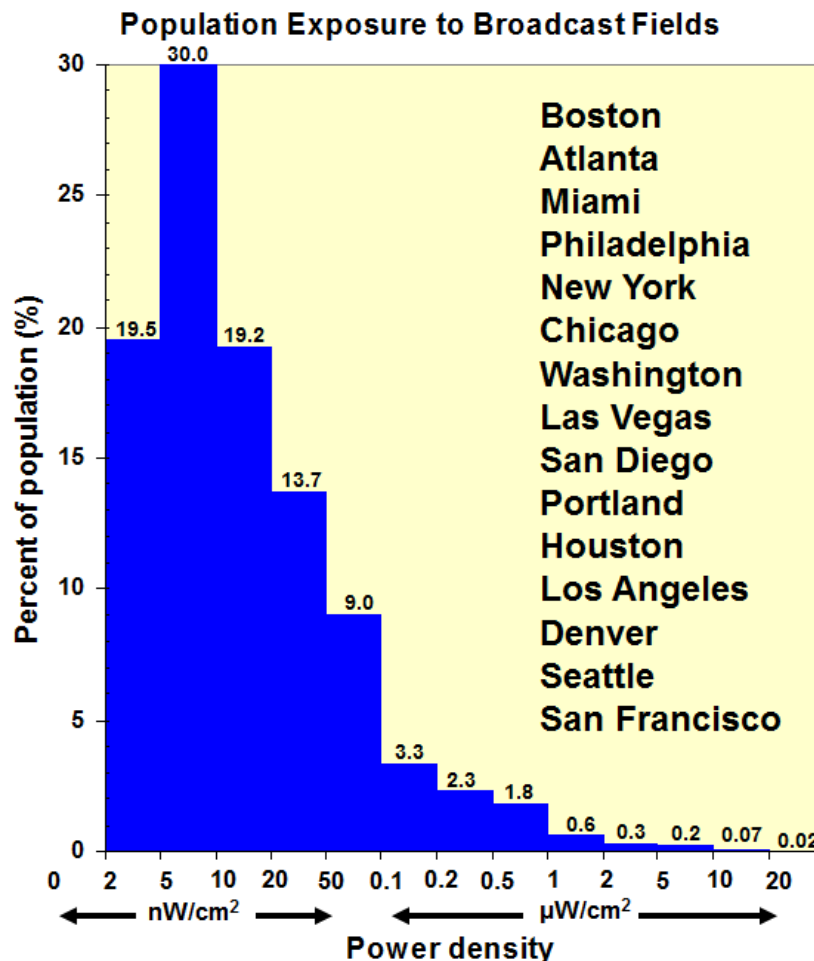


Figure 9. Population exposure to VHF and UHF broadcast RF fields in the U.S. Adapted from Figure 7 in Tell, R.A. and E.D. Mantiplay (1980), Population exposure to VHF and UHF broadcast radiation in the United States, *Proceedings of the IEEE*, Vol. 68, No. 1, January, pp. 6-12.

243: There is no need to recommend minimizing exposure below present SAR based limits. The safety factor of 50 associated with the present SAR based lower tier exposure values, for the general public, are already so far below the threshold of established adverse biological effects as to represent a practical zero probability of harmful effect.

250: If the FCC recommends that a manual, for a portable communications device, provide instructions and advisory statements so the user is aware of body-worn requirements for RF exposure compliance, how does this relate to the requirement that barriers be erected to avoid exposure above public limits at wireless transmitter sites? This appears inconsistent since in one case only advisory statements be used while in another, engineering controls are required to insure compliance. Note that exposure to a cell phone likely results in a greater local SAR within the body than does typical whole body exposure at a wireless or broadcast site.

251: It is stated that exposures “exceeding the SAR limits should not necessarily create an unsafe condition” and “should not be viewed with significantly greater concern than compliant use” since the exposure limits were set with a large safety factor to be well below a threshold for unacceptable rises in tissue temperature! This perspective would argue against such aggressive compliance measures found in other parts of the document as the requirement to install positive access control (barriers) to inhibit members of the general public from accessing areas within which RF fields could exceed the general public limit. The statement that “a use that possibly results in non-compliance with the SAR limit should not be viewed with significantly greater concern than compliant use” is inconsistent with other parts of the document where absolute control is required to avoid exceeding public exposure limits.

P. 99: The terminology “appropriate training” needs clarification since the “training” might be able to be accomplished via simple written information, such as on a sign or the provision of an RF safety information sheet to be given to those entering the site.

2.1093(d)(1)(ii), page 101: “visual advisories on portable devices designed only for occupational use can be used as part of an applicant’s evidence of the device user’s awareness of occupational/controlled exposure limits.” Because there is no inherent biological difference between members of the general public and those that are occupationally exposed to RF, the use of visual advisories supports the concept that appropriate signage should be sufficient at transmitter sites to provide the awareness necessary for individuals to occupy areas in which the RF fields exceed the FCC’s general population exposure limit.

1.1307(b)(2)(ii), page 106: It is unclear whether positive access control is required for the example rooftop with limited access where a sign on the antenna is stated as sufficient “mitigation”. Further, the terminology “...rooftop with limited access...” needs definition. What is meant by “limited” access? The use of signage is stated as representing “sufficient mitigation” of potential RF exposure exceeding the general population exposure limit. The terminology “under certain controlled conditions” must be defined. The language, once again, implies that signage could be sufficient for compliance with the general population MPE without positive access control as required elsewhere in the document.

1.1307(b)(2)(ii), page 107: The text “...to ensure compliance with the time-averaged general population exposure limit” should be clarified to be consistent with earlier requirements relative to the instantaneous peak value of exposure (see paragraph 183, and comment).

1.1307(b)(2)(iii), page 107: It seems that positive access control is not being called for and that signage can be sufficient. If members of the general public have access, in a transient manner at the site, would positive

access control be required? Again, the time-averaged value of exposure should not have any limitation on the instantaneous peak value of RF field.

1.1307(b)(2)(iv), page 107: It appears that the use of lockout/tagout procedures are only required for Category 4 exposure scenarios. The same should apply to Category 3 if power reduction is not feasible such that exposure category reduction is not feasible.

1.1307(b)(2)(v)(B), page 107: It should be noted that the triangle used to surround the RF energy advisory symbol is not used on the NOTICE sign since there is no expectation that exposure less than the upper tier can cause adverse biological effects. See C95.2-1999, section 5.7, second paragraph.

1.1307(b)(2)(i), page 108: An outline of the content requirements of an EA needs to be provided.

2.1093(d)(4), page 115: If visual advisories, on a device for occupational use, are sufficient evidence of the device user's awareness of occupational/controlled exposure limits, signs at a site should also be sufficient to indicate awareness of any individual to occupational/controlled exposure limits.

Page 197: The FCC states that the spatial peak field should be used at locations close to antennas where spatial averaging of fields may not be appropriate because the local SAR limit may be exceeded. This new requirement will have substantial impact on compliance assessments at transmitter sites such as broadcast and wireless base stations where, heretofore, spatial averaging has typically been the only metric used in the determination of compliance. While, undoubtedly, a simpler measurement method, this recommendation will be very challenging and potentially result in erroneous compliance assessments. In general, there is currently no fixed distance from a source or defined exposure geometry for which it can be assumed that local SAR will always comply with the local SAR limit. As a consequence, in the interest of conservatism, many compliance measurements will be made entirely on the basis of spatial peak values of field. This practice will result in larger regions in the vicinity of transmitting antennas wherein it will be assumed that RF fields may exceed either the FCC general population or occupational exposure limits in terms of local SAR. This, in turn, will likely mean that more extensive barriers, signage and training (or providing of RF safety information) will be required at additional cost to transmitter operators. Such overly conservative, and unnecessary, measures will result unless specific guidance can be provided that relates the local RF field strength (or plane wave equivalent power density) to maximum possible local SAR within the body. The FCC should specify a dosimetry based limit in terms of peak RF field strength or plane wave equivalent power density. This will allow compliance assessments to be performed with minimal impact over the current approach of measuring the spatially averaged field. The spatially averaged field remains the primary criterion for compliance unless the local peak field exceeds an FCC specified value.

EXHIBIT N:

**EXAMPLE MPE COMPLIANCE EVALUATION REPORT DID NOT
INCLUDE A ROOFTOP ANALYSIS**



PINNACLE TELECOM GROUP

Professional and Technical Services

APPLICATION NO. _____
DEPT. OF BUILDING
OCT 25 2012

ANTENNA Site FCC RF Compliance ASSESSMENT AND REPORT

PREPARED FOR

NEW YORK SMSA LIMITED PARTNERSHIP
d/b/a VERIZON WIRELESS

"EAST MEADOW 3" SITE
2545 HEMPSTEAD TURNPIKE
EAST MEADOW, NY

201214287

APPLICATION NO. _____
DEPT. OF BUILDING

SEPTEMBER 19, 2012

OCT 25 2012

TOWN OF HEMPSTEAD
BUILDING DEPT. CONCEIVED

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Appendix A. BACKGROUND ON THE FCC MPE Limit

201214287
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Appendix B. NOTE ON POTENTIAL RF INTERFERENCE

OCT 21 2012

Appendix C. SUMMARY of EXPERT QUALIFICATIONS

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INTRODUCTION AND SUMMARY

At the request of New York SMSA Limited Partnership d/b/a Verizon Wireless ("Verizon Wireless"), Pinnacle Telecom Group has performed an independent expert assessment of radiofrequency (RF) levels and related FCC compliance for the modification of an existing wireless base station antenna operation on a building rooftop at 2545 Hempstead Turnpike in East Meadow, NY. Verizon Wireless refers to the site as "East Meadow 3" and the antenna modifications are proposed so Verizon Wireless can effectively operate under its FCC-licensed frequencies, including 700 MHz, 850 MHz, and 1900 MHz.

The FCC requires wireless system operators to perform an assessment of potential human exposure to radiofrequency (RF) fields emanating from all the transmitting antennas at a site whenever antenna operations are added or modified, and to ensure compliance with the Maximum Permissible Exposure (MPE) limit in the FCC regulations. In this case, the compliance analysis needs to include the RF effects of other existing antenna operations at the site by AT&T and T-Mobile.

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This report describes a mathematical analysis of compliance with the FCC MPE limit for safe continuous exposure of the general public. The RF effects of the antennas are calculated using a standard FCC formula – and the analysis is designed to conservatively overstate the RF levels that actually occur from the antennas. In that way, as long as the results indicate RF levels below the MPE limit, we can have great confidence the compliance requirement is satisfied.

The results of a compliance assessment can be explained in layman's terms by describing the calculated RF levels as simple percentages of the FCC MPE limit. If the reference for that limit is 100 percent, then calculated RF levels higher than 100 percent indicate the MPE limit is exceeded, while calculated RF levels consistently lower than 100 percent serve as a clear and sufficient demonstration of compliance with the MPE limit. We will also describe the overall worst-case calculated result via the "plain-English" equivalent "times-below-the-limit factor".

The results of the FCC RF compliance assessment in this case are as follows:

- The conservatively calculated maximum RF level from the Verizon Wireless antenna operations as modified, along with the other antenna operations at the site, is 4.3124 percent of the FCC MPE limit – well below the 100-percent reference for compliance. In other words, even with the significant degree of conservatism incorporated in the analysis, the worst-case calculated overall RF level is still more than 23 times below the FCC limit established as safe for continuous human exposure to the RF emissions from antennas.
- The results of the calculations provide a clear demonstration that the RF levels from the combination of proposed and existing antenna operations at the site satisfy the applicable criteria for controlling potential human exposure to RF fields, and the RF levels will be in clear compliance with the FCC regulations and limit concerning RF safety. Moreover, because of the conservative methodology and incorporated assumptions, RF levels actually caused by the antennas will be even less significant than the calculation results here indicate.

The remainder of this report provides the following:

- relevant technical data on the Verizon Wireless antenna operations, as modified, and on the other existing antenna operations at the site
- a description of the applicable FCC mathematical model for assessing MPE compliance, and application of the relevant technical data to that model; and
- the results of the analysis, and the compliance conclusion for the site.

In addition, three appendices are included. Appendix A provides background on the FCC MPE limit, along with a list of FCC references on compliance, and Appendix B provides a description of why no RF interference will occur to other facilities. Appendix C provides a summary of the expert qualifications of the author of this report.

ANTENNA AND TRANSMISSION DATA

The table below provides the key compliance-related data for the Verizon Wireless antenna operations, as modified, at the site.

General Data	
Frequency Bands	700 MHz, 850 MHz and 1900 MHz
Service Coverage Type	Sectorized
Antenna Type	Directional Panel
Antenna Centerline Heights AGL	52 ft.
700 MHz Antenna Data	
Antenna Model / Maximum Gain	CSS X7C-FRO-440 / 16.4 dBi CSS X7C-FRO-460 / 16.1 dBi
RF Channels per Sector	1
Transmitter Power / RF Channel	40 watts
850 MHz Antenna Data	
Antenna Model / Maximum Gain	CSS X7C-FRO-440 / 16.4 dBi CSS X7C-FRO-460 / 16.1 dBi
RF Channels per Sector	8
Transmitter Power / RF Channel	20 watts
1900 MHz Antenna Data	
Antenna Model / Maximum Gain	CSS AXP18-60 / 17.8 dBi CSS AXP19-45 / 18.9 dBi
RF Channels per Sector	4
Transmitter Power / RF Channel	16 watts

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Note that in the compliance analysis, we will conservatively ignore the power-attenuation effects associated with the antenna cabling ("antenna line loss".)

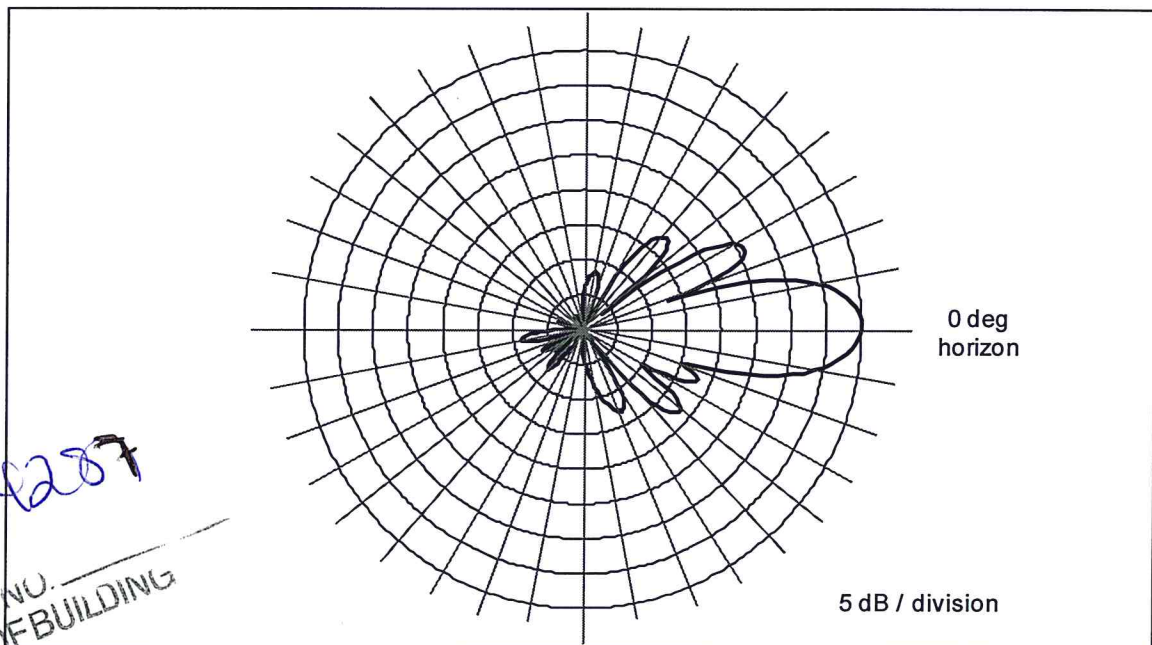
The antenna vertical-plane radiation pattern is used in the calculations of RF levels at ground level around a site. Figures 1 through 4 that follow show the vertical-plane radiation patterns of the Verizon Wireless antenna models in each frequency band of interest. (For both the CSS X7C-FRO-440 and X7C-FRO-460 antennas, the manufacturer specifies a single pattern covering both the 700 MHz and 850 MHz frequency bands.)

Note that in this type of diagram, the antenna is effectively pointed at the three o'clock position (the horizon) and the relative strength of the pattern at different angles is described using decibel units.

The use of a decibel scale to describe the relative pattern at different angles incidentally tends to visually understate the actual focusing effects of the antenna. Where the antenna pattern reads 20 dB, for example, the relative RF energy emitted at the corresponding downward angle is $1/100^{\text{th}}$ of the maximum that occurs in the main beam (at 0 degrees); at a 30 dB point, the level is $1/1,000^{\text{th}}$ of the maximum.

Finally, note that the automatic pattern-scaling feature of our internal software may skew side-by-side visual comparisons of different antenna models, or even different parties' depictions of the same antenna model.

Figure 1. CSS X7C-FRO-440 Antenna – 700/850 MHz Vertical-plane Pattern



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Figure 2. CSS X7C-FRO-460 Antenna – 700/850 MHz Vertical-plane Pattern

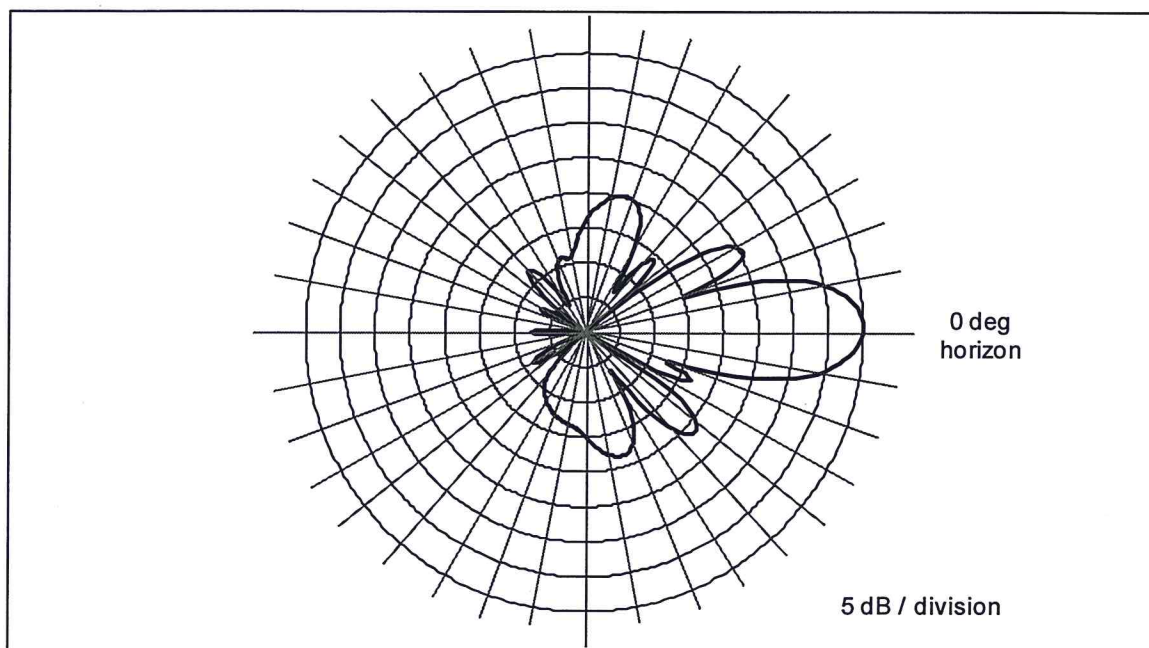
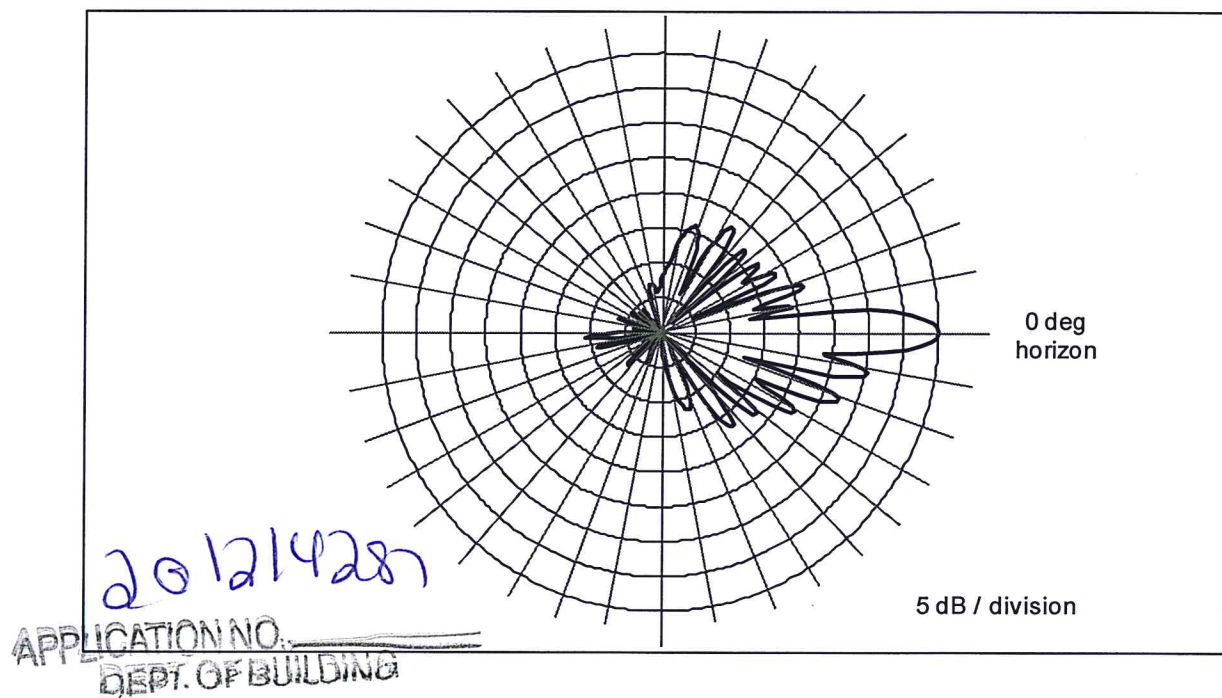


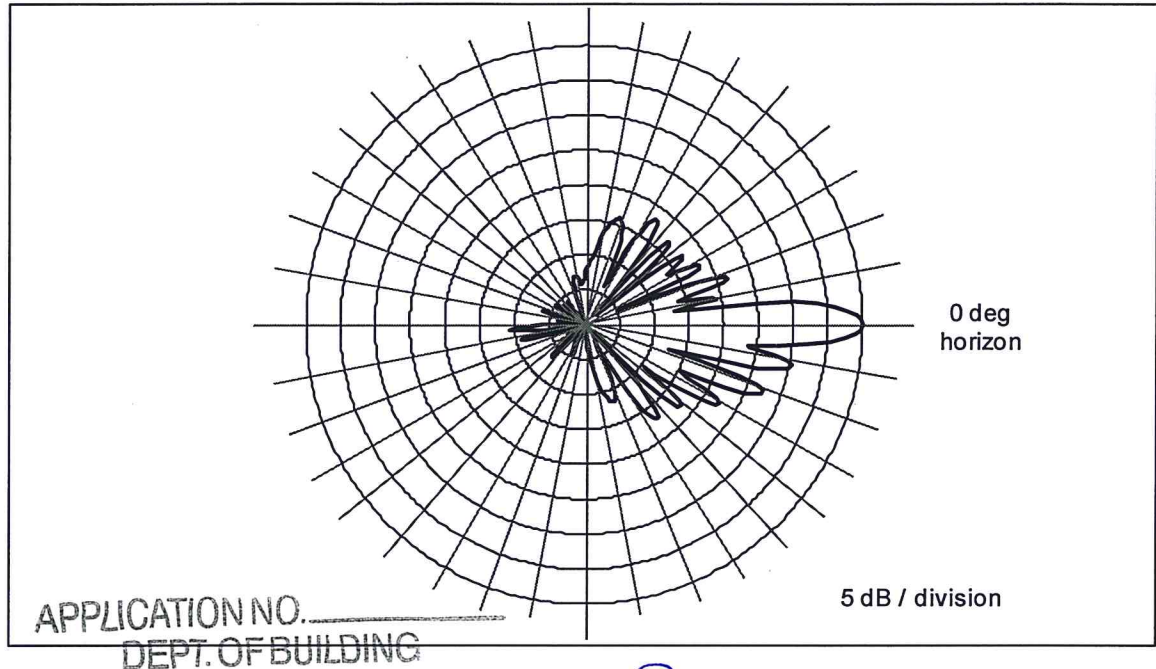
Figure 3. CSS AXP18-60 Antenna – 1900 MHz Vertical-plane Pattern



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Figure 4. CSS AXP19-45 Antenna – 1900 MHz Vertical-plane Pattern



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As noted at the outset, there are other existing wireless antenna operations at the site to include in the compliance assessment. In the analysis for each of the wireless carriers, we will conservatively assume operation with maximum channel capacity and at maximum transmitter power in each of their respective FCC-licensed frequency bands.

AT&T is licensed to operate in the 700, 850 and 1900 MHz frequency bands. In the 700 MHz band, AT&T uses as many as four RF channels per antenna sector and a maximum transmitter power of 40 watts. In the 850 MHz band, AT&T uses as many as eight RF channels per antenna sector and a maximum transmitter power of 20 watts. In the 1900 MHz band, AT&T uses as many as four RF channels per antenna sector, with a maximum of 16 watts of transmitter power per channel.

T-Mobile is licensed to operate in the 1900 MHz and 2100 MHz frequency bands. In the 1900 MHz band, T-Mobile uses a maximum of eight RF channels in each antenna sector, with a maximum transmitter power of 20 watts per channel. In

the 2100 MHz band, T-Mobile uses two channels per sector, with a maximum of 40 watts of transmitter power per channel.

Compliance Analysis

FCC Office of Engineering and Technology Bulletin 65 ("OET Bulletin 65") provides guidelines for mathematical models to calculate the RF levels at various points around transmitting antennas. At street-level around an antenna site (in what is called the "far field" of the antennas), the RF levels are directly proportional to the total antenna input power and the relative antenna gain in the downward direction of interest – and the levels are otherwise inversely proportional to the square of the straight-line distance to the antenna. Conservative calculations also assume the potential RF exposure is enhanced by reflection of the RF energy from the ground. Our calculations will assume a 100% "perfect" reflection, the worst-case approach.

The FCC's formula for street-level RF compliance calculations for any given wireless antenna operation is as follows:

$$\text{MPE\%} = (100 * \text{TxPower} * 10^{(\text{Gmax-Vdisc}/10)} * 4) / (\text{MPE} * 4\pi * R^2)$$

where

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- | | | |
|-------------------------------|---|--|
| MPE% | = | RF level, expressed as a percentage of the MPE limit applicable to continuous exposure of the general public |
| 100 | = | factor to convert the raw result to a percentage |
| TxPower | = | maximum net power into antenna sector, in milliwatts, a function of the number of channels per sector, the transmitter power per channel, and line loss |
| $10^{(\text{Gmax-Vdisc}/10)}$ | = | numeric equivalent of the relative antenna gain in the downward direction of interest, referenced to any applied antenna mechanical downtilt; data on the antenna vertical-plane pattern is taken from manufacturer specifications |
| 4 | = | factor to account for a 100-percent-efficient energy reflection from the ground, and the squared relationship between RF field strength and power density ($2^2 = 4$) |

MPE = FCC general population MPE limit

R = straight-line distance from the RF source to the point of interest, centimeters

The MPE% calculations are performed out to a distance of 500 feet from the facility to points 6.5 feet (approximately two meters, the FCC-recommended standing height) off the ground, as illustrated in Figure 5, below.

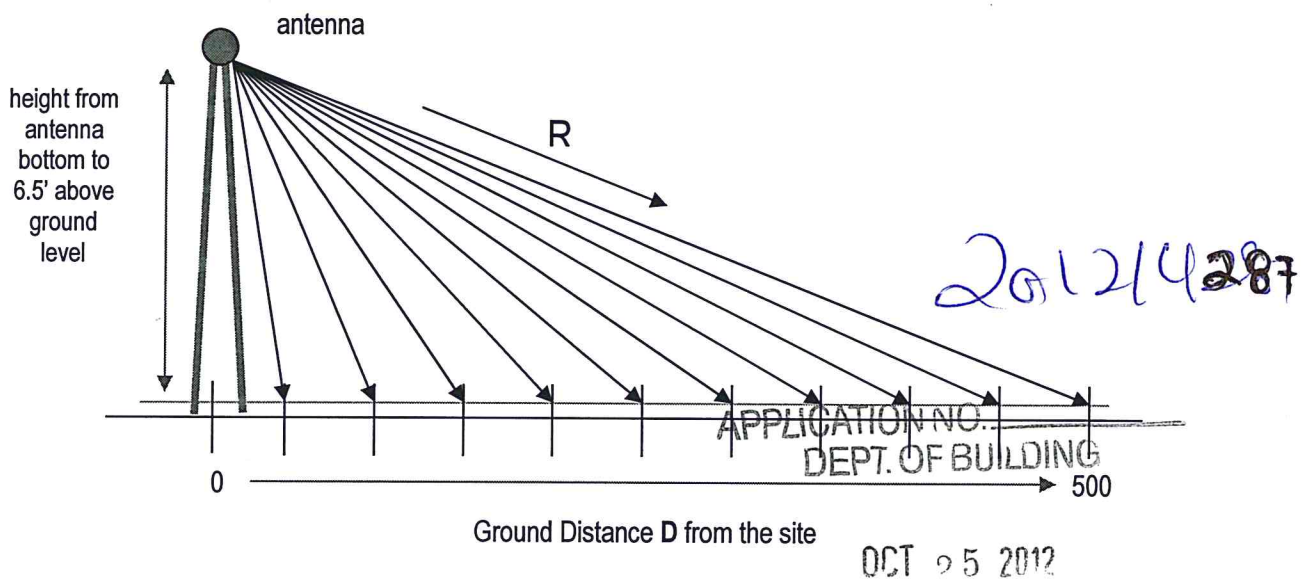


Figure 5. MPE% Calculation Geometry

It is popularly understood that the farther away one is from an antenna, the lower the RF level – which is generally but not universally correct. The results of MPE% calculations fairly close to the site will reflect the variations in the vertical-plane antenna pattern as well as the variation in straight-line distance to the antennas. Therefore, RF levels may actually increase slightly with increasing distance within the range of zero to 500 feet from the site. As the distance approaches 500 feet and beyond, though, the antenna pattern factor becomes less significant, the RF levels become primarily distance-controlled, and as a result the RF levels generally decrease with increasing distance, and are well understood to be in compliance.

FCC compliance for a collocated antenna site is assessed in the following manner. At each distance point along the ground, an MPE% calculation is made for the RF effect from each party's antenna operation, and the sum of the individual MPE% contributions at each point is compared to 100 percent, the normalized reference for compliance with the MPE limit. We refer to the sum of the individual MPE% contributions as "total MPE%", and any calculated total MPE% result exceeding 100 percent is, by definition, higher than the FCC limit and represents non-compliance and a need to mitigate the potential exposure. If all results are consistently below 100 percent, on the other hand, that set of results serves as a clear and sufficient demonstration of compliance with the MPE limit. Note that according to the FCC, when directional antennas and sectorized coverage arrangements are used, the compliance assessments are based on the RF effect of a single antenna sector (or, in cases of non-identical parameters, the worst-case effect of any individual sector).

The following conservative methodology and assumptions are incorporated into the MPE% calculations on a general basis:

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1. The antennas are assumed to be operating continuously at maximum power, and at maximum channel capacity. In addition, the effects of antenna line loss are ignored wherever possible.
 2. The power-attenuation effects of shadowing or other obstructions to the line-of-sight path from the antenna to the point of interest are ignored.
 3. The calculations intentionally minimize the distance factor (R) by assuming a 6'6" human and performing the calculations from the bottom (rather than the centerline) of each operator's lowest-mounted antenna, as applicable.
 4. The potential RF exposure at ground level is assumed to be 100-percent enhanced (increased) via a "perfect" field reflection from the intervening ground.

The net result of these assumptions is to significantly overstate the calculated RF exposure levels relative to the levels that will actually occur – and the purpose of this conservatism is to allow very "safe-side" conclusions about compliance.

In addition in this case, we have taken into account the different characteristics and RF effects of multiple antenna models used in the same frequency band.

The table below provides the results of the MPE% calculations for each operator, with the overall worst-case result highlighted in bold in the last column.

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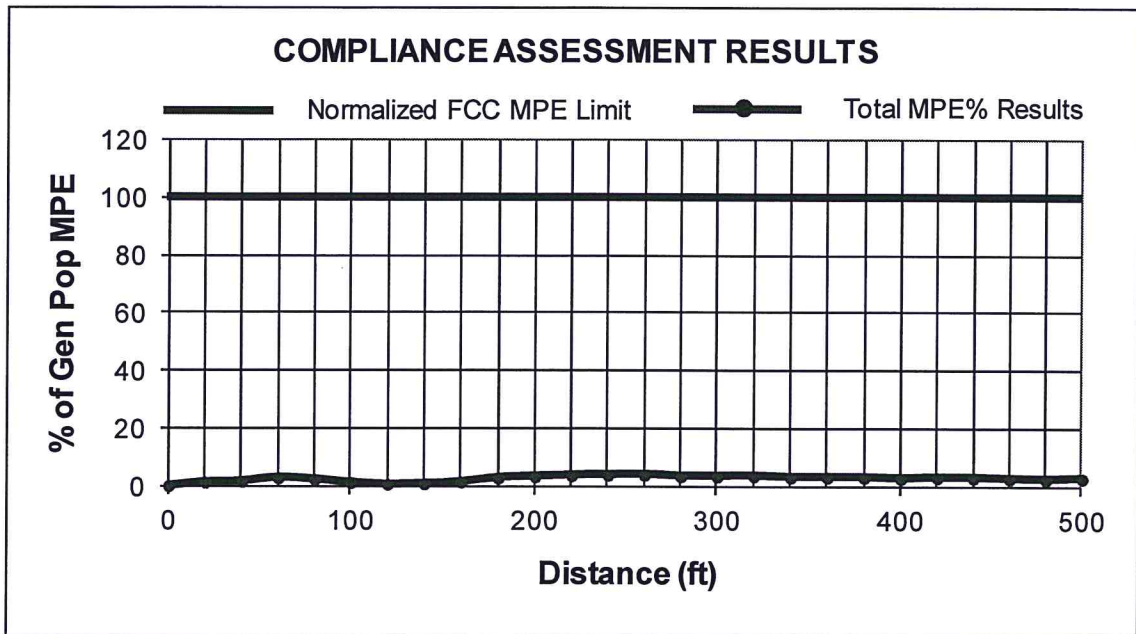
Ground Distance (ft)	Verizon Wireless 700 MHz MPE%	Verizon Wireless 850 MHz MPE%	Verizon Wireless 1900 MHz MPE%	AT&T MPE%	T-Mobile MPE%	Total MPE%
0	0.1802	0.1555	0.0013	0.0706	0.1019	0.5095
20	0.2413	0.2083	0.0734	1.0804	0.1218	1.7252
40	0.2628	0.2268	0.0210	1.3367	0.1802	2.0275
60	0.1007	0.0869	0.0520	2.8360	0.1353	3.2109
80	0.0334	0.0288	0.1982	2.3639	0.1037	2.7280
100	0.0657	0.0567	0.4577	0.8524	0.1919	1.6244
120	0.0257	0.0222	0.4404	0.3216	0.2658	1.0757
140	0.0447	0.0386	0.0440	0.6503	0.4838	1.2614
160	0.1392	0.1201	0.0533	1.2139	0.3340	1.8605
180	0.3003	0.2592	0.3636	2.0597	0.2338	3.2166
200	0.3553	0.3066	0.4204	2.3424	0.2804	3.7051
220	0.4181	0.3608	0.3840	2.5686	0.3409	4.0724
240	0.4879	0.4211	0.2700	2.7770	0.3311	4.2871
260	0.5380	0.4643	0.1459	2.9112	0.2530	4.3124
280	0.5999	0.5178	0.0538	2.5200	0.1738	3.8653
300	0.5242	0.4524	0.0471	2.6400	0.1519	3.8156
320	0.5553	0.4793	0.0396	2.7185	0.1687	3.9614
340	0.4929	0.4254	0.0351	2.4133	0.1498	3.5165
360	0.5295	0.4570	0.0865	2.1565	0.3235	3.5530
380	0.4759	0.4107	0.0777	2.2713	0.2908	3.5264
400	0.4301	0.3712	0.0702	2.0526	0.2627	3.1868
420	0.4484	0.3870	0.1757	1.8639	0.5682	3.4432
440	0.4089	0.3529	0.1602	1.9494	0.5182	3.3896
460	0.3744	0.3231	0.1467	1.7851	0.4745	3.1038
480	0.3441	0.2970	0.1348	1.6407	0.4361	2.8527
500	0.3644	0.3145	0.2481	1.5131	0.7697	3.2098

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As indicated, even with the significant degree of conservatism built into the calculations, the maximum calculated overall RF level is 4.3124 percent of the FCC MPE limit – well below the 100-percent reference for compliance.

A graph of the overall calculation results, provided on the next page, probably provides a clearer *visual* illustration of the relative insignificance of the calculated

RF levels. The line representing the calculated total MPE% results shows an obviously clear and consistent margin to the FCC MPE limit.



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Compliance Conclusion

According to the FCC, the MPE limit has been constructed in such a manner that continuous human exposure to RF emissions up to and including 100 percent of the MPE limit is acceptable and safe.

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As described, the analysis in this case shows that the maximum calculated RF level from the combination of proposed and existing antenna operations is 4.3124 percent of the FCC MPE limit. In other words, the worst-case calculated RF level from the antenna operations is more than 23 times below the limit established as safe for continuous human exposure to the RF emissions from antennas.

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The results of the calculations provide a clear demonstration of compliance with the FCC MPE limit. Moreover, because of the conservative calculation methodology and operational assumptions we applied in the analysis, RF levels

actually caused by the antennas will be even less significant than the calculation results here indicate.

CERTIFICATION

It is the policy of Pinnacle Telecom Group that all FCC RF compliance assessments are reviewed, approved, and signed by the firm's Chief Technical Officer, who certifies as follows:

1. I have read and fully understand the FCC regulations concerning RF safety and the control of human exposure to RF fields (47 CFR 1.1301 *et seq*).
2. To the best of my knowledge, the statements and information disclosed in this report are true, complete and accurate.
3. The analysis of site RF compliance provided herein is consistent with the applicable FCC regulations, additional guidelines issued by the FCC, and industry practice.
4. The analysis provides a clear demonstration of compliance with the FCC regulations and limit concerning potential human exposure to the RF emissions from antennas.


Daniel J. Collins
Chief Technical Officer

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Date

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Appendix A. Background on the FCC MPE Limit

FCC Rules and Regulations

As directed by the Telecommunications Act of 1996, the FCC has established limits for maximum continuous human exposure to RF fields.

The FCC maximum permissible exposure (MPE) limits represent the consensus of federal agencies and independent experts responsible for RF safety matters. Those agencies include the National Council on Radiation Protection and Measurements (NCRP), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the American National Standards Institute (ANSI), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). In formulating its guidelines, the FCC also considered input from the public and technical community – notably the Institute of Electrical and Electronics Engineers (IEEE).

The FCC's RF exposure guidelines are incorporated in Section 1.301 *et seq* of its Rules and Regulations (47 CFR 1.1301-1.1310). Those guidelines specify MPE limits for both occupational and general population exposure.

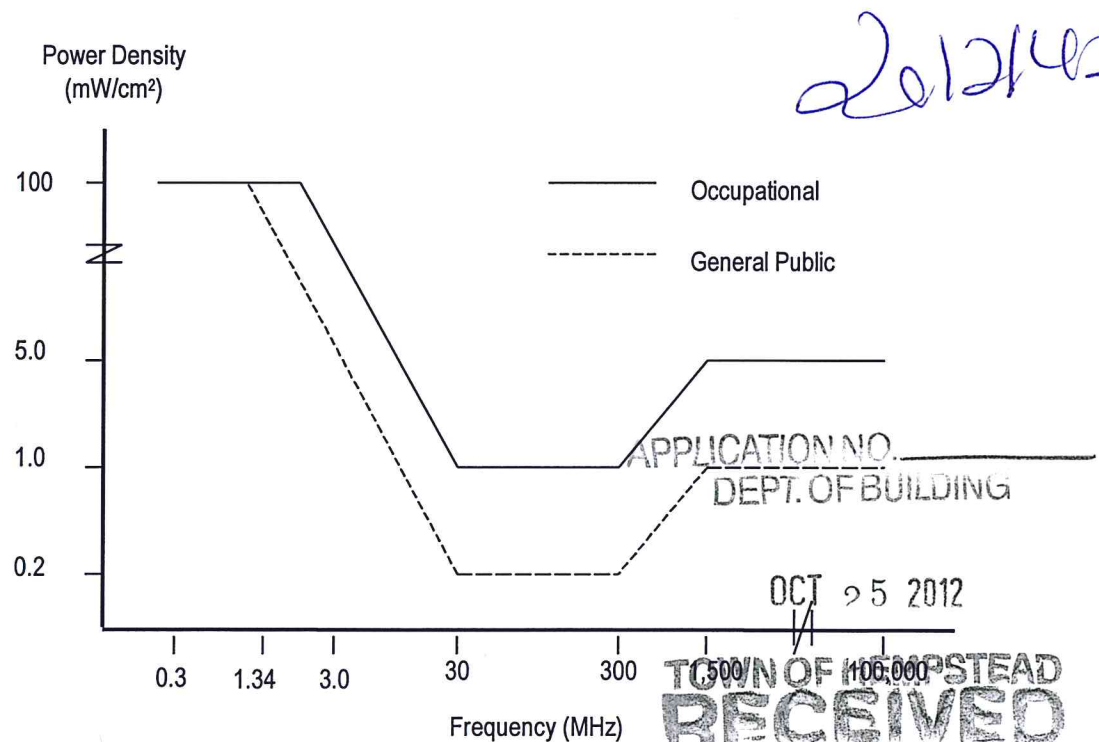
The specified continuous exposure MPE limits are based on known variation of human body susceptibility in different frequency ranges, and a Specific Absorption Rate (SAR) of 4 watts per kilogram, which is universally considered to accurately represent human capacity to dissipate incident RF energy (in the form of heat). The occupational MPE guidelines incorporate a safety factor of 10 or greater with respect to RF levels known to represent a health hazard, and an additional safety factor of five is applied to the MPE limits for general population exposure. Thus, the general population MPE limit has a built-in safety factor of more than 50. The limits were constructed to appropriately protect humans of both sexes and all ages and sizes and under all conditions – and continuous exposure at levels equal to or below the applicable MPE limits is considered to result in no adverse health effects or even health risk.

The reason for two tiers of MPE limits is based on an understanding and assumption that members of the general public are unlikely to have had appropriate RF safety training and may not be aware of the exposures they receive; occupational exposure in controlled environments, on the other hand, is assumed to involve individuals who have had such training, are aware of the exposures, and know how to maintain a safe personal work environment.

The FCC's RF exposure limits are expressed in two equivalent forms, using alternative units of field strength (expressed in volts per meter, or V/m), and power density (expressed in milliwatts per square centimeter, or mW/cm²). The table on the next page lists the FCC limits for both occupational and general population exposures, using the mW/cm² reference, for the different radio frequency ranges.

Frequency Range (F) (MHz)	Occupational Exposure (mW/cm ²)	General Public Exposure (mW/cm ²)
0.3 - 1.34	100	100
1.34 - 3.0	100	$180 / F^2$
3.0 - 30	$900 / F^2$	$180 / F^2$
30 - 300	1.0	0.2
300 - 1,500	$F / 300$	$F / 1500$
1,500 - 100,000	5.0	1.0

The diagram below provides a graphical illustration of both the FCC's occupational and general population MPE limits.



Because the FCC's MPE limits are frequency-shaped, the exact MPE limits applicable to the instant situation depend on the frequency range used by the systems of interest.

The most appropriate method of determining RF compliance is to calculate the RF power density attributable to a particular system and compare that to the MPE limit applicable to the operating frequency in question. The result is usually expressed as a percentage of the MPE limit.

For potential exposure from multiple systems, the respective percentages of the MPE limits are added, and the total percentage compared to 100 (percent of the limit). If the result is less than 100, the total exposure is in compliance; if it is more than 100, exposure mitigation measures are necessary to achieve compliance.

Note that the FCC "categorically excludes" certain types of antenna facilities from the routine requirement to specifically (i.e., mathematically) demonstrate compliance with the MPE limit. Among those types of facilities are cellular antennas mounted on any type of tower, when the bottoms of the antennas are more than 10 meters (c. 32.8 feet) above ground. The basis for the categorical exclusion, according to the FCC, is the understanding that because of the low power and the directionality of the antennas, such facilities – individually and collectively – are well understood to have no significant effect on the human environment. As a result, the FCC automatically deems such facilities to be in compliance.

FCC References on Compliance

47 CFR, FCC Rules and Regulations, Part 1 (Practice and Procedure), Section 1.1310 (Radiofrequency radiation exposure limits).

FCC Second Memorandum Opinion and Order and Notice of Proposed Rulemaking (FCC 97-303), *In the Matter of Procedures for Reviewing Requests for Relief From State and Local Regulations Pursuant to Section 332(c)(7)(B)(v) of the Communications Act of 1934 (WT Docket 97-192)*, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation (ET Docket 93-62), and Petition for Rulemaking of the Cellular Telecommunications Industry Association Concerning Amendment of the Commission's Rules to Preempt State and Local Regulation of Commercial Mobile Radio Service Transmitting Facilities, released August 25, 1997.

FCC First Memorandum Opinion and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released December 24, 1996.

FCC Report and Order, ET Docket 93-62, *In the Matter of Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, released August 1, 1996.

FCC Office of Engineering and Technology (OET) Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 97-01, August 1997.

Appendix B. NOTE ON POTENTIAL RF INTERFERENCE

In connection with the RF emissions from the Verizon Wireless antenna operation, we note that Verizon Wireless has been granted by the FCC exclusive geographic rights to its channel frequencies, and is further subject to strict FCC technical standards on parameters such as maximum power and out-of-band emissions, as well as regulations related to non-interference.

Therefore, we can provide a clear assurance that the Verizon Wireless antenna operation does not and will not interfere with public safety communications, or the usual and customary reception of radio, television, or other communications services enjoyed by the nearby residential and non-residential properties, or other existing telecommunications devices.

At the same time, however, we would be professionally remiss in omitting a reference to a July 2003 FCC decision – a “Memorandum Opinion and Order” in “WT Docket No. 02-100” that related to interference. That FCC Order concluded that any local ordinance requiring a certification of non-interference related to a wireless antenna siting application represents “impermissible regulation” of RF interference, an area under exclusive FCC jurisdiction and federally-preempted from local regulation.

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Appendix C. SUMMARY of EXPERT QUALIFICATIONS

Daniel J. Collins, Chief Technical Officer, Pinnacle Telecom Group, LLC

Synopsis:	<ul style="list-style-type: none"> • 40 years of experience in all aspects of wireless system engineering, related regulation, and RF exposure • Has performed or led RF exposure compliance assessments on more than 17,000 antenna sites since the new FCC rules went into effect in 1997 • Has provided testimony as an RF compliance expert more than 1,400 times since 1997 • Accepted as an expert in New York, New Jersey, Connecticut, Pennsylvania and more than 40 other states, as well as by the FCC
Education:	<ul style="list-style-type: none"> • B.E.E., City College of New York (Sch. Of Eng.), 1971 • M.B.A., 1982, Fairleigh Dickinson University, 1982 • Bronx High School of Science, 1966
Current Responsibilities:	<ul style="list-style-type: none"> • Leads all PTG staff work involving RF safety and FCC compliance, microwave and satellite system engineering, and consulting on wireless technology and regulation
Prior Experience:	<ul style="list-style-type: none"> • Edwards & Kelcey, VP – RF Engineering and Chief Information Technology Officer, 1996-99 • Bellcore, Executive Director – Regulation and Public Policy, 1983-96 • AT&T (Corp. HQ), Director – Spectrum Management Policy and Practice, 1977-83 • AT&T Long Lines, Group Supervisor – Microwave Radio System Design, 1972-77
Specific RF Safety / Compliance Experience:	<ul style="list-style-type: none"> • Involved in RF exposure matters since 1972 • Have had lead corporate responsibility for RF safety and compliance at AT&T, Bellcore, Edwards & Kelcey, and PTG • While at AT&T, helped develop the mathematical models later adopted by the FCC for predicting RF exposure • Have been relied on for compliance by all major wireless carriers, as well as by the federal government, several state and local governments, equipment manufacturers, system integrators, and other consulting / engineering firms
Other Background:	<ul style="list-style-type: none"> • Author, <i>Microwave System Engineering</i> (AT&T, 1974) • Co-author and executive editor, <i>A Guide to New Technologies and Services</i> (Bellcore, 1993) • National Spectrum Managers Association (NSMA) – former three-term President and Chairman of the Board of Directors; was founding member, twice-elected Vice President, a long-time member of the Board of Directors, and was named an NSMA Fellow in 1991 • Listed in <i>Who's Who in the Media and Communication</i> and <i>International Who's Who in Information Technology</i> • Published more than 35 articles in industry magazines

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EXHIBIT O:

PICTURE OF 2545 HEMPSTEAD TURNPIKE, EAST MEADOW, NY



EXHIBIT P:
ACCESS IN FRONT OF ANTENNAS
2631 MERRICK ROAD, BELLMORE, NY



EXHIBIT Q:

FCC ET DOCKET NO. 03-137
COMMENTS FROM EDWIN D. HILL



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EDWIN D. HILL
International President

SAM J. CHILIA
International
Secretary-Treasurer

April 4, 2014

Ex Parte

Marlene H. Dortch
Secretary, Federal Communications Commission
445 12th Street SW
Washington, DC 20554

**Re: Proposed Changes in the Commission's Rules Regarding
Human Exposure to Radiofrequency Electromagnetic Fields,
ET Docket No. 03-137**

Dear Ms. Dortch:

The International Brotherhood of Electrical Workers (IBEW) requested a meeting with Federal Communications Commission (FCC) staff to discuss issues associated with the ongoing proposed rulemaking regarding the above docket. On March 12, 2014, James Tomaseski, Director of the IBEW's Safety and Health Department, along with Doug Williams, Chairman and CEO of RF CHECK, Inc. (RF CHECK), Drew Fountain, Co-Founder and Vice Chairman of RF CHECK, Daniel Jaurigue, President, North America of RF CHECK, and Roger Egan, Executive Chairman of Risk Strategies Co., met with Julius Knapp, Joe Monie, Bruce Romano, Robert Weller, Ed Mantiply, and Martin Doczkat, all of whom are of the FCC's Office of Engineering and Technology. The meeting was specifically set up to discuss the adoption of safe harbors for roof-top and other locations, as well as to discuss the continuing problem with third party worker exposure to harmful RF emissions.

The IBEW specifically commended the FCC for pursuing rulemaking. The IBEW agreed with the Commission that the proposal was a step in the right direction as it addresses workers' exposure to RF emissions. The IBEW also cautioned that if safe harbor provisions were granted to carriers where untrained and uninformed workers could be unnecessarily exposed to RF radiation, the purpose of the rulemaking would be jeopardized and would result in a step in the wrong direction.

Roger Egan explained that property insurers will not accept a partial solution. Unless a comprehensive solution protecting the needs of all the wireless stakeholders is implemented that would not only be limited to roof-top sites, insurers will react in a predictable manner by denying coverage to property owners who host wireless antennas. He concluded that exclusions would be very disruptive to network expansion demands at a time when all consumers want and need increased wireless capacity and coverage.



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Marlene H. Dortch
April 4, 2014
Page 2

The IBEW has been involved in this debate for several years. The IBEW has been diligent in our efforts to keep the Commission and cellular service providers aware of the issue of the pointless third party worker exposure to RF radiation hazards, and the fact that RF CHECK offers a simple, effective, state-of-the-art solution to this problem. Included in this filing are documents that the IBEW presented during the meeting which demonstrate our efforts to explain the need for a comprehensive RF safety system that should be supported by the industry.

This letter is being submitted pursuant to the Commission's rules for inclusion in the public record of the above-referenced proceeding.

Sincerely yours,

Edwin D. Hill
International President

EDH:mra
Copy to James Tomaseski, Director, Safety and Health Department



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EDWIN D. HILL
International President

LINDELL K. LEE
International
Secretary-Treasurer

August 11, 2008

Ms. Marlene Dortch, Secretary
Federal Communications Commission
445 12th Street, SE
Washington, DC 20554

**Re: Applications of Atlantis Holdings, LLC, transferor and Celco
Partnership D/B/A/ Verizon Wireless, transferee, WT Docket 08-95.**

Dear Chairman Martin and Commissioners:

In order to protect workers from dangerous working conditions that violate Federal Communications Commission ("FCC" or "Commission") rules, the International Brotherhood of Electrical Workers ("IBEW") writes today to respectfully urge the Commission to reject the proposed merger of Atlantis Holdings LLC ("Alltel") and Celco Partnership D/B/A/ Verizon Wireless ("Verizon Wireless").

IBEW represents approximately 750,000 members who work in every state of the nation and in a wide variety of fields, including utilities, construction, telecommunications, broadcasting, manufacturing, railroads and government. The IBEW was formed in 1891 and takes great pride in its members' central role in building our nation's telecommunications infrastructure. IBEW linemen strung the telephone wires on which we all rely. IBEW craftsmen built our telephones. IBEW telephone operators ran the first manual switches – then IBEW technicians built and maintained the complex switching machinery which makes telecommunications possible.

We are always mindful, however, that building the country's telecommunications network has, at each stage of technological development, exposed our members to risk due to substandard safety practices by building owners, network operators, and equipment providers. Therefore, IBEW has worked for more than 100 years for critical safety improvements.

Today's great challenge is to balance the construction of a nationwide wireless network with the need to protect workers, both those employed by wireless carriers and third-party workers who may be exposed to dangerous RF signals above the established FCC limits. Verizon Wireless and Alltel have not achieved this balance and unnecessarily expose workers to unsafe conditions.

The Commission has explained that in reviewing proposed transactions it will apply a public interest test that asks, in part: "whether the transaction would result in a violation of the Commission's rules."¹ When the rule at issue is one that protects public safety, the Commission should be at its most vigilant. Congress, in the first lines of the Communications Act of 1934, states that it created the FCC for, among other purposes, the purpose of "promoting safety of life and property through the use of wire and radio." As the Commission has stated on many occasions, protecting public safety is a paramount responsibility of the FCC.

¹ *SBC-Ameritech Merger Order*, 14 FCC Rcd. 14737-38 ¶ 48.



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Ms. Marlene Dortch
August 11, 2008
Page 2

IBEW has thousands of workers that perform their duties on or near Verizon Wireless and Alltel antenna facilities every day. On a daily basis, our IBEW membership and other third party workers perform duties on rooftops, utility poles, light standards, and other structures that bring them in to close proximity to Verizon Wireless and Alltel RF transmitting antennas.

The RF exposure limits set forth in 47 CFR 1.1310 apply to all FCC licensed facilities, including those of Verizon Wireless and Alltel.² As a condition for transferring licenses, wireless carriers must certify that they comply with FCC rules including those that prevent the exposure of persons above the FCC human exposure limits.³ The limits are well known to all wireless licensees. The FCC's whitepaper on "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields" ("OET 65") forewarns licensees that persons will be exposed above the FCC limits if they are allowed to access areas that are too close to active antennas. The FCC assumes persons will not have close access to antennas, or that if they do, procedures will be in place to control exposures to below FCC limits.⁴ Verizon Wireless encourages its site owners to restrict access by the use of locks to rooftops and other structures, thus claiming FCC RF exposure compliance. However, our IBEW membership is still granted access to these areas and is still being potentially over-exposed to RF emissions. All licensees must, under FCC rules, therefore take the "actions necessary" to bring the accessible areas that exceed the FCC exposure limits into compliance. This is the shared responsibility of all licensees whose transmission power density levels exceed 5% of the applicable FCC exposure limit.⁵

Over the years the number of sites and antennas across the country has skyrocketed. Antennas occupy not only difficult-to-access towers, but also rooftops, sides of buildings and other structures constantly accessed by our IBEW membership as well as roofers, painters, HVAC, carpenters, sheet metal workers and firefighters. The increasing number of "stealth" antennas and co-located sites exacerbate the problem of identifying and understanding RF risks.

Verizon Wireless and Alltel have an aggressive safety program to protect their own employees from the RF risk created by their antennas. However, the licensees do not afford the same level of precaution for third-party workers. For example, Verizon Wireless workers are provided extensive ongoing RF safety training, are routinely provided with RF protection monitors, and are informed of the location and danger presented by antennas in their working environment. Verizon routinely powers down their antennas when their employees are in close proximity to these RF transmitters. This safeguard is not provided by Verizon Wireless to our IBEW membership or third party workers. According to the Commission's license agreements, Verizon Wireless has a clear, non-delegable obligation to ensure that no worker – employee or third party – is over-exposed to RF radiation from their transmitting antennas.

² 47 CFR 1.1307(b)(1)

³ 47 CFR 1.1307(b)

⁴ OET 65, page 13, par. 3.

⁵ 47 CFR 1.1307(b)(3)



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Ms. Marlene Dortch
August 11, 2008
Page 3

FCC precedent is clear that a transaction should not be approved in the face of continuing rule violations. As a result of Verizon Wireless failure to adhere to the FCC's license RF exposure obligations, the Commission should not approve the merger.

If the Commission determines that the merger should be approved, it should grant the applications subject to the condition that the merged company immediately adopt a nation-wide RF safety system that protects all workers.

The IBEW feels that without a comprehensive RF safety system, which can be administered and verified by a neutral third party, RF over-exposures will continue to pose unnecessary health risks.

The IBEW appreciates the FCC's prompt attention to this important regulatory and safety and health concern.

Sincerely yours,

A handwritten signature in black ink, which appears to read "Edwin Hill", is written over a horizontal line.

Edwin Hill
International President

EDH:dmm



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Washington, DC 20001
202.833.7000
<http://www.ibew.org>

EDWIN D. HILL
International President

LINDELL K. LEE
International
Secretary-Treasurer

November 18, 2008

Mr. Ralph de la Vega
Chief Executive Officer
AT&T Mobility
Glenridge Highlands Two
Atlanta, GA 30342

Dear Mr. de la Vega:

The International Brotherhood of Electrical Workers (IBEW) and its membership fully appreciate the importance of wireless communications and your company's continuing network expansion activities. The IBEW has no objection to expanding the number of wireless antennas and, in fact, encourages the industry to continue its growth. At the same time, I must ensure that our members are protected against radiofrequency (RF) radiation over-exposure while performing their duties around Federal Communications Commission (FCC) licensees' antennas.

I realize that there are practical challenges your company faces in order to provide adequate safety protection for IBEW members. However, as an FCC licensee, *your company is required to ensure that "no worker be over-exposed to RF radiation."* This is an obligation of all FCC licensees that cannot be delegated, and applies to all workers, whether they are employees of your company or third party workers. I have attached the August 11, 2008 IBEW filing before the FCC regarding the Alltel/Verizon Wireless merger, which contains a more detailed explanation of each licensee's RF safety responsibilities.

I am committed to working with the wireless industry collaboratively to overcome the challenges of achieving adequate protection for our members. With this in mind, the IBEW and other trade unions affected by RF over-exposure have been in contact with RF CHECK, Inc., a San Diego company that specializes in RF radiation safety and compliance. I have observed the maturation of their database and now firmly believe their protocol is the only practical solution for IBEW members, third party workers, and all FCC licensees. RF CHECK's technology is the only system that is capable of providing current site-specific RF safety information to all workers at all FCC licensee transmission sites. Uncoordinated, individual corporate systems based on yesterday's technologies just cannot do the job, especially with the unique challenges faced by third party workers.

With the explosion of wireless antennas across our nation, the time has come for a new and technically advanced RF safety system that will protect the health of IBEW members and third party workers.



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Ralph de la Vega
November 18, 2008
Page 2

The IBEW respectfully requests that you, your COO or CFO meet with RF CHECK to fully understand how their system functions. It is in the best interest of all FCC licensees, those that host wireless facilities, and those who can be affected by RF radiation over-exposure.

The IBEW thanks you in advance for this courtesy. You may contact Doug Williams, CEO of RF CHECK at 619-840-5548.

Sincerely yours,

A handwritten signature in dark ink, which appears to read "Edwin D. Hill". The signature is fluid and cursive, with a large initial "E" and "H".

Edwin D. Hill
International President

EDH:dmm
Attachment



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EDWIN D. HILL
International President

LINDELL K. LEE
International
Secretary-Treasurer

November 18, 2008

Mr. Lowell C. McAdam
President and Chief Executive Officer
Verizon Wireless
One Verizon Way
Basking Ridge, NJ 07920

Dear Mr. McAdam:

The International Brotherhood of Electrical Workers (IBEW) and its membership fully appreciate the importance of wireless communications and your company's continuing network expansion activities. The IBEW has no objection to expanding the number of wireless antennas and, in fact, encourages the industry to continue its growth. At the same time, I must ensure that our members are protected against radiofrequency (RF) radiation over-exposure while performing their duties around Federal Communications Commission (FCC) licensees' antennas.

I realize that there are practical challenges your company faces in order to provide adequate safety protection for IBEW members. However, as an FCC licensee, your company is required to ensure that "no worker be over-exposed to RF radiation." This is an obligation of all FCC licensees that cannot be delegated, and applies to all workers, whether they are employees of your company or third party workers. I have attached the August 11, 2008 IBEW filing before the FCC regarding the Alltel/Verizon Wireless merger, which contains a more detailed explanation of each licensee's RF safety responsibilities.

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Lowell C. McAdam
November 18, 2008
Page 2

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Sincerely yours,

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Edwin D. Hill
International President

EDH:dmm
Attachment





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EDWIN D. HILL
International President

LINDELL K. LEE
International
Secretary-Treasurer

November 18, 2008

Mr. Daniel R. Hesse
President and Chief Executive Officer
Sprint Nextel Corporation
6200 Sprint Parkway
Overland Park, KS 66251

Dear Mr. Hesse:

The International Brotherhood of Electrical Workers (IBEW) and its membership fully appreciate the importance of wireless communications and your company's continuing network expansion activities. The IBEW has no objection to expanding the number of wireless antennas and, in fact, encourages the industry to continue its growth. At the same time, I must ensure that our members are protected against radiofrequency (RF) radiation over-exposure while performing their duties around Federal Communications Commission (FCC) licensees' antennas.

I realize that there are practical challenges your company faces in order to provide adequate safety protection for IBEW members. However, as an FCC licensee, your company is required to ensure that "no worker be over-exposed to RF radiation." This is an obligation of all FCC licensees that cannot be delegated, and applies to all workers, whether they are employees of your company or third party workers. I have attached the August 11, 2008 IBEW filing before the FCC regarding the Alltel/Verizon Wireless merger, which contains a more detailed explanation of each licensee's RF safety responsibilities.

I am committed to working with the wireless industry collaboratively to overcome the challenges of achieving adequate protection for our members. With this in mind, the IBEW and other trade unions affected by RF over-exposure have been in contact with RF CHECK, Inc., a San Diego company that specializes in RF radiation safety and compliance. I have observed the maturation of their database and now firmly believe their protocol is the only practical solution for IBEW members, third party workers, and all FCC licensees. RF CHECK's technology is the only system that is capable of providing current site-specific RF safety information to all workers at all FCC licensee transmission sites. Uncoordinated, individual corporate systems based on yesterday's technologies just cannot do the job, especially with the unique challenges faced by third party workers.

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Daniel R. Hesse
November 18, 2008
Page 2

The IBEW respectfully requests that you, your COO or CFO meet with RF CHECK to fully understand how their system functions. It is in the best interest of all FCC licensees, those that host wireless facilities, and those who can be affected by RF radiation over-exposure.

The IBEW thanks you in advance for this courtesy. You may contact Doug Williams, CEO of RF CHECK at 619-840-5548.

Sincerely yours,

Edwin D. Hill
International President

EDH:dmm
Attachment



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EDWIN D. HILL
International President

LINDELL K. LEE
International
Secretary-Treasurer

November 18, 2008

Mr. Robert Dotson
Chief Executive Officer
T-Mobile USA
12920 SE 38th Street
Bellevue, WA 98006

Dear Mr. Dotson:

The International Brotherhood of Electrical Workers (IBEW) and its membership fully appreciate the importance of wireless communications and your company's continuing network expansion activities. The IBEW has no objection to expanding the number of wireless antennas and, in fact, encourages the industry to continue its growth. At the same time, I must ensure that our members are protected against radiofrequency (RF) radiation over-exposure while performing their duties around Federal Communications Commission (FCC) licensees' antennas.

I realize that there are practical challenges your company faces in order to provide adequate safety protection for IBEW members. However, as an FCC licensee, your company is required to ensure that "no worker be over-exposed to RF radiation." This is an obligation of all FCC licensees that cannot be delegated, and applies to all workers, whether they are employees of your company or third party workers. I have attached the August 11, 2008 IBEW filing before the FCC regarding the Alltel/Verizon Wireless merger, which contains a more detailed explanation of each licensee's RF safety responsibilities.

I am committed to working with the wireless industry collaboratively to overcome the challenges of achieving adequate protection for our members. With this in mind, the IBEW and other trade unions affected by RF over-exposure have been in contact with RF CHECK, Inc., a San Diego company that specializes in RF radiation safety and compliance. I have observed the maturation of their database and now firmly believe their protocol is the only practical solution for IBEW members, third party workers, and all FCC licensees. RF CHECK's technology is the only system that is capable of providing current site-specific RF safety information to all workers at all FCC licensee transmission sites. Uncoordinated, individual corporate systems based on yesterday's technologies just cannot do the job, especially with the unique challenges faced by third party workers.

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Robert Dotson
November 18, 2008
Page 2

The IBEW respectfully requests that you, your COO or CFO meet with RF CHECK to fully understand how their system functions. It is in the best interest of all FCC licensees, those that host wireless facilities, and those who can be affected by RF radiation over-exposure.

The IBEW thanks you in advance for this courtesy. You may contact Doug Williams, CEO of RF CHECK at 619-840-5548.

Sincerely yours,

A handwritten signature in cursive script, reading "Edwin D. Hill", is written over a horizontal line.

Edwin D. Hill
International President

EDH:dmm
Attachment





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EDWIN D. HILL
International President

LINDELL K. LEE
International
Secretary-Treasurer

November 18, 2008

Mr. Scott T. Ford
President and Chief Executive Officer
Alltel Corporation
One Allied Drive
Little Rock, AR 72202

Dear Mr. Ford:

The International Brotherhood of Electrical Workers (IBEW) and its membership fully appreciate the importance of wireless communications and your company's continuing network expansion activities. The IBEW has no objection to expanding the number of wireless antennas and, in fact, encourages the industry to continue its growth. At the same time, I must ensure that our members are protected against radiofrequency (RF) radiation over-exposure while performing their duties around Federal Communications Commission (FCC) licensees' antennas.

I realize that there are practical challenges your company faces in order to provide adequate safety protection for IBEW members. However, as an FCC licensee, your company is required to ensure that "no worker be over-exposed to RF radiation." This is an obligation of all FCC licensees that cannot be delegated, and applies to all workers, whether they are employees of your company or third party workers. I have attached the August 11, 2008 IBEW filing before the FCC regarding the Alltel/Verizon Wireless merger, which contains a more detailed explanation of each licensee's RF safety responsibilities.

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Scott T. Ford
November 18, 2008
Page 2

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The IBEW thanks you in advance for this courtesy. You may contact Doug Williams, CEO of RF CHECK at 619-840-5548.

Sincerely yours,

A handwritten signature in cursive script, reading "Edwin D. Hill", is positioned below the "Sincerely yours," text.

Edwin D. Hill
International President

EDH:dmm
Attachment



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EDWIN D. HILL
International President

SAM J. CHILIA
International
Secretary-Treasurer

January 2, 2012

Mr. David Michaels, PhD, MPH
Assistant Secretary of Labor for OSHA
U.S. Department of Labor
Occupational Safety and Health Administration
200 Constitution Ave., NW
Washington, DC 20210

Re: RF Radiation Hazards

Dear Dr. Michaels:

The International Brotherhood of Electrical Workers (IBEW) and its membership fully appreciate the importance of your agency supporting the objective of employers providing a safe work environment for their employees. I would like to take this opportunity to share my concerns regarding the hazards related to radio frequency (RF) radiation from RF transmitting antennas across our nation.

The IBEW is committed to working with employers and the Federal Communications Commission (FCC) licensees (governmental and commercial) to overcome the challenges of protecting workers from RF radiation hazards. The IBEW recognizes that there are practical challenges that we all face in order to achieve the goal of implementing a comprehensive national RF safety protocol.

All FCC licensees' are required to ensure that, "no worker be over-exposed to RF radiation." This FCC obligation is non-delegable and applies to all individuals who may come in close proximity to RF transmitting antennas. However, on a daily basis IBEW members are compelled to work in close proximity to RF transmitting antennas without a comprehensive RF safety solution in place.

None of us can deny the proliferation of wireless and the vast number of RF transmitting antennas that exist across our nation nor can we deny the need for a new RF safety protocol that will protect the health and safety of our IBEW members and other third party workers.

The IBEW's Safety and Health Director, James Tomaseski, met with your agency regarding this issue with the specific goal of garnering OSHA's support for a comprehensive national RF safety protocol. During these meetings, it was identified that OSHA's own employees are also exposed to the same RF radiation hazards in question.



**INTERNATIONAL
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Mr. David Michaels, PhD, MPH
January 2, 2012
Page 2

The IBEW and other trade unions whose members are affected by RF radiation over-exposure have been in contact with RF CHECK, Inc., a San Diego based company that specializes in RF radiation safety and compliance. RF CHECK has patented a dynamic database solution that we believe is the *only* protocol to provide comprehensive, site specific RF safety information to our membership and others who may work in close proximity to RF transmitting antennas.

RF CHECK's patented RF safety solution does not burden employers, what so ever, in providing a safe work environment for their employees and supports OSHA's own health and safety directives. Their system is furnished at *no-cost* to all users including all workers, employers, FCC licensees, site owners, federal, state, and local agencies, school districts, airports, first responders, banking, utility and insurance industry, and others.

It is the IBEW's desire as well as other trade unions to gain OSHA's full support on this national RF safety protocol, and encourage OSHA to continue to work with RF CHECK in addressing this serious national RF safety issue

Thank you for your cooperation. If you should have any questions regarding this request, please contact James Tomaseski, IBEW Safety and Health Director at (202) 728-6040.

Sincerely yours,

Edwin D. Hill
International President

EDH:dmm
Copy to James R. Tomaseski, Director, IBEW Safety and Health Department

**BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of

Reassessment of Federal Communications Commission
Radiofrequency Exposure Limits and Policies

ET Docket No. 13-84

Proposed Changes in the Commission's Rules
Regarding Human Exposure to Radiofrequency Electromagnetic Fields ET Docket No. 03-137

**COMMENTS OF THE
INTERNATIONAL BROTHERHOOD OF ELECTRICAL WORKERS
(IBEW)**

This is in response to the FCC's Notice of Proposed Rule Making regarding radiofrequency exposures. Although the FCC is requesting comments with cost benefit considerations for their proposals, we would like to go on record as noting that many of the existing regulations have no practical application to provide RF safety or FCC compliance for IBEW members. We also believe that many of the proposed RF compliance rules and regulations will not result in improved RF safety for our members or increased FCC licensee compliance and accountability.

Please accept the following comments as our concern regarding our member's exposure to RF radiation and the lack of any RF safety solution for existing or proposed FCC RF Human Exposure Standards.

In reference to paragraphs to Paragraphs 177, 178, 196, 199 and others that refer to CFR 47 1.1310, we offer the following:

1. The premise that an IBEW member, whether considered under general population or a transient individual might have knowledge that there is an allowable FCC RF exposure limit for them and that they would fall under any certain category, either general population exposure limits or occupational exposure is inaccurate for the following reasons:
 - a. In reference to CFR 47 1.1310 and refer to Table 1—Limits for Maximum Permissible Exposure (MPE) (see below), IBEW members and many other workers will not know to refer to this chart.
 - b. The FCC licensee should be responsible for ensuring our members are aware of their exposure so they can fully exercise control over their exposure. The FCC licensee should also be responsible for ensuring our member knows the unique physical boundaries at every work location so as not to exceed the referenced RF exposure limits.

2. The premise that an IBEW member would be able use the table to determine how to remain safe from RF exposure at any particular location is inaccurate as follows:
 - a. Assuming that an IBEW member was able to determine his/her allowable exposure limits as referenced above, how would they know where the RF exposure areas were located at a particular site which host RF transmitting antennas?
 - b. How would an IBEW member know where the exposure areas are located that would exceed the applicable limits?
3. Also, is it not correct that voice RF transmissions can occur with variable power where the power could fluctuate up or down at any instant? So, would it not be safe to say that assuming the RF power density is static would be wrong and would not be an applicable way to be in compliance with existing or proposed FCC RF Human exposure limits? Therefore, any site specific RF safety information should be based upon maximum output power as a default to avoid any confusion on RF allowable RF exposure levels.
4. In reference to notification and signs as noted in paragraphs 175, 178, 182, 185, 192, 194, 196, 198, 200, 201 and others we have the following comments:
 - a. It's our understanding that the FCC only recommends signs but does not require signs. What should be required is that a person be made aware of their potential exposure so they can exercise control over their exposure.
 - b. Signs in many existing work areas are very ambiguous and are not RF exposure specific. It appears that the FCC licensees only place these signs as a general warning; however, they are not protecting IBEW members from being exposed above the allowable limits and should not be considered to be a "catch all" for FCC RF compliance. In addition, how does a sign protect IBEW members who are not on a rooftop but are working near a pole attached antenna, or one on the side of a building, or a water tank or a stealth antenna blended into the architecture of the building?
 - c. When there is a hazard, the hazard creator has a duty to warn others against the hazard. Signs and notification are an important part of any safety program as they can provide warning of a hazard. However, because there is no way to assure that a worker has read or understand the information on a sign and there's no current method to insure that a sign contains enough information to ensure compliance with the FCC MPE exposure limits, signs should not be considered to be utilized as providing comprehensive RF compliance and safety.
 - d. Notification is the key, but how to notify and ensure the notification was received must be considered.

5. In reference to paragraph 193 we have the following comments:

- a. Although the FCC licensee is ultimately responsible for ensuring that no individual is exposed above their RF radiation FCC limits (and the IBEW believes this as a non-delegable duty that cannot be passed onto the property owner), it only makes sense that providing real and effective RF safety for any individual should be a “shared responsibility” maintained between the regulators (FCC, OSHA, EPA, Congress), the FCC licensee, the property owner or property management company, the employer or subcontractor and the employee.
- b. This Notice of Proposed Rule Making Change is long overdue and validates that ensuring compliance with existing FCC RF human exposure limits by the FCC licensee is not effective and cannot/is not being enforced.
- c. As evidence of this situation, we are beginning to assess our member’s potential RF exposures, past and present, as we believe that many of our members have been exposed to levels of RF radiation in excess of the FCC limits.
- d. We have considered numerous solutions to address RF safety for our members and have concluded, the only effective method is what RF CHECK, Inc. has patented. We recommend (as we did to OSHA), that all the parties work with RF CHECK to ensure accountability for the FCC’s RF Human Exposure laws and for the protection of our nation’s workforce.

Thank you for the opportunity to comment on these proposed rules and we commend the Commission for reviewing these exposure rules that should provide better protection for workers in the future.

Respectfully submitted,



Edwin D. Hill
International President
International Brotherhood of Electrical Workers (IBEW)
900 Seventh Street, NW
Washington, DC 20001
202-833-7000

Submitted September 11, 2013